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ORIGINAL ARTICLES.

I.—On some more Fossil Estheriæ.

By Professor T. Rupert Jones, F.R.S., F.G.S., etc.

(PLATE II.)

Introduction.
Estheria membranacea of the Old Red, Orkney.
Estheria Andrewsii of the Purbeck, Wilts.
Estheria Hindei of the Trias, Pennsylvania.
Estheria minuta (*Germari*?) of the Trias, Saxony.
——— ——— var. *Brodieana* of the Trias, Cheshire.
Estheriella.
Estheriella costata } of the Trias, Saxony.
Estheriella nodocostata }
Bibliographic history of the *Estheriellæ*.

In the September Number of the Geological Magazine, 1890,[1] I offered some notes on certain Triassic *Estheriæ* of North America and Bavaria, and on an *Estheria* from the Purbeck strata of Wiltshire. An interesting example of *E. membranacea* from the Old Red of Orkney was figured, but not described. We have now the Rev. W. R. Andrews's other Purbeck *Estheria*, referred to at p. 389, ready for description; another Triassic *Estheria* from Pennsylvania; and some most interesting specimens of the rare *Estheriella*, instituted as a subgenus by the late Professor Dr. Ch. Ernst Weiss.

Seeing the account of *Estheria Lewisii* in the Geol. Mag., *loc. cit.*, Dr. G. J. Hinde, F.G.S., remembered some specimens he had collected in Pennsylvania, and these I find to be from the same place (Phœnixville) as supplied Mr. C. M. Wheatley with a series for my Monograph in 1862; but Dr. Hinde's examples show structure not seen in any of the others.

Having met with a peculiar structure in some Carboniferous *Estheriæ* from Scotland, which seemed to correspond with the descriptions of that in *Estheriella*, I asked the late Prof. E. Weiss for information on the subject; and, though confined to bed by illness, he most courteously gave his attention to my request, and not only sent me (in February, 1890) some specimens of the rare fossil, but obtained permission, from the Director of the Geological Institute and Mining Academy at Berlin, for me to have on loan some of the best specimens from the Geological-Survey Museum, to figure and describe. I deeply regret that we have to bring out the

[1] Decade III. Vol. VII. pp. 385–390, Pl. XII.

results of the examination without consultation with Prof. Weiss, whose death a large circle of friends and admirers had to deplore last summer.

Of *Estheria minuta* and some other forms of that genus I gave some notes in the Geol. Mag. Decade II. Vol. V. 1878, pp. 100–102, Pl. III. Figs. 1, 2, and now, besides the notices referred to above, I have to make mention of Mr. C. E. De Rance's discovery of this species in the lower part of the "Keuper Marls" of Cheshire,—a lower horizon for England than had been previously known.

1. Estheria membranacea (Pacht). Geol. Mag. September, 1890. Pl. XII. Fig. 9.

Jones, Monograph of the Fossil Estheriæ, Pal. Soc. 1862, pp. 14-22, pl. i. figs. 1-7.

Length 6 (hinge-line 5), height 4 mm.

This little fossil has been noticed by P. N. Wenjukoff in his Memoir "On the Fauna of the Devonian System in North-western and Central Russia," 8vo. St. Petersburgh, 1886, pp. 223–4 (in Russ). In the synonymy he gives *Posidonia aspera*, Kutorga, 1852, instead of "*Posidonomya rugosa*, Kutorga," of the list at p. 14 of the "Monograph Foss. Estheriæ." We may note that Raimund Pacht in the "Archiv Natur. Liv.-, Ehst- und Kurlands," vol. ii. 2nd part, 1859 ("1861" in Wenjukoff's list, *op. cit.* p. 224), treating of the Devonian Limestone in Livland (Livonia), describes and figures *E. membranacea*, at pp. 290–291, and in figs. 7*a*, *b*, *c*, of the plate (not numbered), as "*Posidonia membranacea*, n. sp.=*P. rugosa*, Kut., auf der Karte des St.-Petersb. Gouv."

It was remarked at p. 21 of the "Monogr. Foss. Esth." that in the Russian (or rather Livonian) specimens "the thin upstanding concentric riblets are better preserved than in the flagstones of Caithness." Some individuals, however, from Orkney, collected by Mr. Jex, and now in the British Museum, show the ornamentation so clearly that Fig. 9 of Pl. XII. in the Geol. Mag. for September, 1890, was specially given, though not described at the time, only alluded to at p. 390. This figure not only shows the longer, or more oblong, shape of the valve, referred to in the "Monograph" at pp. 14 and 15, but a very delicately reticulate interstitial sculpturing, such as was supposed (at pp. 15 and 19) to have been modified by the impress of sand grains in the matrix at Caithness.

2. Estheria Andrewsii, sp. nov. Pl. II. Figs. 1–4.

Fig. 1.—Length 8·5 (hinge-line 6), height 6 mm.
Fig. 2.— ,, 11·5 (,, 9), ,, 7 mm.

These specimens, from the Purbeck beds of the Vale of Wardour, as also those described in the Geol. Mag. for September, 1890, p. 389, Pl. XII. Figs. 1, 2, were collected by the Rev. W. R. Andrews, F.G.S., in a quarry at Teffont-Ewyas, Wilts, but in a different stratum of the Middle-Purbeck formation, namely, in a dark shaly clay, containing *Cypridea fasciculata* and *C. punctata*, five feet below the horizon of the *Estheria* referred to above.

The former specimens were referable to *E. subquadrata* (Sow.),

by their shape and ornament; but those now under notice are larger; one individual is approximately subquadrate in shape (Fig. 1), but the other is more elongate (Fig. 2); both have the umbo further from the anterior extremity, and otherwise differ from *E. subquadrata* and *E. elliptica* in being less fully curved at the antero-ventral region and in being higher behind than in front. Further, they have a delicate reticulation for the interstitial ornament (Fig. 3). This finely punctate sculpture, however, belonging to the superficial layer of the test, gives an impression on the matrix, at some places, of a delicate linear granulation, making very small, vertical, interrupted striæ; whilst the inside of this outer layer shows a coarser pitting (Fig. 4).

Specimens numerous, squeezed flat, but fairly well preserved, on the thin laminæ of a bluish grey, soft shale, with brownish partings, and with white patches of the decomposed *Cypridææ*.

3. Estheria Hindei, sp. nov. Pl. II. Figs. 5–8.

Length 7 (hinge-line 5), height 4·5 mm.

An elegant suboblong *Estheria*, boldly rounded in front, narrower behind; rather more than half egg-shaped in a longitudinal aspect. Umbo at the antero-dorsal corner. Concentric riblets (15 visible) strong and far apart, and at some spots seen to be neatly beaded, but rarely so regularly and distinct as in Fig. 6. The interspaces are bare of ornament; but the inner layer of the test in some instances shows irregular vertical rows of small lumpy elevations (Fig. 7), which are probably exaggerations (in the older part of the valve) of small vertical irregular bars (Fig. 8), in the interspaces elsewhere. This last-mentioned columnar ornament is analogous to that shown in fig. 37, pl. ii. of the Monogr. Foss. Estheriæ, and referred to at page 387, Geol. Mag. September, 1890.

The specimens under notice are numerous in a hard, black, thinly-laminated Triassic shale, from Phœnixville, Pennsylvania (Dr. G. J. Hinde's Collection), like some of that described at p. 99, "Monogr. Foss. Estheriæ," as having been supplied by Mr. C. M. Wheatley from the same locality. Some are better preserved as to shape; but others more distinctly show the structure of the valve. The selected specimen, Fig. 5, is like one of the "narrower" examples mentioned at p. 98 *op. cit.*; and, as with many others, there is no interstitial ornament. In some shiny, black, filmy valves we have the features shown in Figs. 6, 7, 8. The last two belong to the inner layer of tests of apparently different ages, but covered with the outer layer, in which the ornament became obsolete. Hence neither figs. 29 and 30, nor fig. 31 of pl. ii. "Monogr. Foss. Esth." must be taken by themselves for specific characters, though suggested at p. 386 of the Geol. Mag. Sept. 1890.

These specimens from Pennsylvania certainly differ from *Estheria ovata* of the "Monogr. Foss. Esth." p. 84, pl. ii. figs. 26–28, being proportionally longer, and having a less fully semicircular ventral outline. They are larger and proportionally higher (broader) than

E. Lewisii, Geol. Mag. Sept. 1890, p. 385, Pl. XII. Fig. 3, with the umbo further forward and a different ornament. Otherwise these two species, as well as *E. multicostata* (Emmons), "Monogr. Foss. Esth." p. 86, fig. 6, and *E. ovalis* (Emmons), *op. cit.* p. 87, fig. 8, are evidently allied forms, though the last two have most probably been badly drawn.

4. Estheria minuta (Alberti), 1832. Pl. II. Fig. 12.

Jones, Synonymy in the "Monograph of the Fossil Estheriæ, Palæont. Soc. 1862," p. 42; F. von Alberti's "Ueberblick über die Trias," etc., 1864, pp. 191 and 192; Jones, Geological Magazine, Dec. III. Vol. VII. 1890, Pl. XII. Figs. 4–8.

Length 3·0 (hinge-line 2·0), height 1·9 mm.

This is a specimen occurring in the Lower-Bunter shale at Dürrenberg, in Saxony, with *Estheriella costata*, Weiss. It is very much like it, as seen in Fig. 9, but is smaller and has no radial striæ. It has the same number of concentric lines, and therefore cannot be the young of the larger form; and the occurrence of the radii is too persistent among the many *Estheriellæ* in the shale, to allow of the supposition that they constituted merely a casual feature and were not always present in the same series of valves. Fig. 12 may be compared with fig. 8 of pl. v. and fig. 29, and even with fig. 28, of pl. i. of the "Monogr. Foss. Esth." as a specially straight-backed form of the species.

Fig. 12 may possibly be *Estheria Germari* (*Posidonia*, Beyrich, Zeitsch. D. g. Ges. vol. ix. 1857, p. 377), from the Bunter at the Steinberg, north of the Hartz, and at Halle and Dürrenberg, both in Saxony. Andrae, in the Explanation of the Geological Map of Halle, 1850, p. 67, referred to it as *P. minuta*. It is characterized by having a long and straight hinge-border; and according to Prof. Weiss it has no radial markings.

Besides the authors treating of the occurrence of *Estheria minuta* in the German Trias that are enumerated in the "Monogr. Foss. Esth." pp. 44 *et seq.*, we should mention C. von Schauroth, Zeitsch. D. g. Ges. vol. ix. 1857, p. 99 (Coburg).

4*. Estheria minuta (Alberti), var. Brodieana, Jones. Pl. II. Fig. 14.

Monogr. Foss. Estheriæ, 1862, p. 69, pl. ii. figs. 8–15, and pl. v. fig. 10; Geol. Mag. Dec. 3, Vol. VII. 1890, p. 388, Pl. XII. Fig. 6.

Length 3 (hinge-line 2), height 2·5 mm.

Lately Mr. C. E. De Rance, F.G.S., has obtained from the "Old Alderley Quarry," at Alderley Edge, Cheshire, a small shoal-like group of *Estheriæ* in a soft, dull red, finely micaceous shale, belonging to the upper part of the "Keuper Marls," f. 6 of the Geological Survey Map, and a thousand feet lower down in the Trias (being below the waterstones, f. 5) than any of the English examples of *E. minuta* yet found.

The specimens occur both as single valves and in open pairs;

they are much crushed, and Fig. 14 shows one of the best. It is very much like the German specimen figured in the Geol. Mag. for September, 1890, Pl. XII. Fig. 6, and nearly matches fig. 9 of pl. ii. "Monogr. Foss. Esth."

E. minuta, var. *Brodieana*, has been reported by Ferd. Roemer as having been found in the Keuper of Upper Silesia. This, and some other notes on the occurrences of *E. minuta* published since 1862, are given in the Geol. Mag. Dec. II. Vol. V. 1878, p. 102.

E. minuta, var. *Karpinskiana*, Jones, related to var. *Brodieana*, was obtained by Dr. Karpinsky from the Triassic or Rhætic strata of Troizk, on the eastern side of the Ural. See Ann. Mag. Nat. Hist., October, 1883, p. 244, pl. vi. fig. 1.

Estheriella, Weiss (as a subgenus, 1875).

Similar to *Estheria*, excepting that the valves bear radial riblets or slight ledges crossing the concentric striæ from near the umbo to the ventral border.

5. Estheriella costata, Weiss, 1875. Pl. II. Figs. 9, 10, *a*, *b*.

Posidonomya Wengensis, Giebel (non Wissmann). Zeitsch. gesammt. Naturwiss. Halle, 1857, p. 308, pl. ii. fig. 6.
Estheria ? Wengensis, Alberti. Ueberblick Trias, etc., 1864, p. 192. *note*.
Estheria (*Estheriella*) *costata*, Weiss. Zeitsch. D. g. Gesellsch. vol. xxvi. 1875, p. 711, *note*.
Estheriella costata, Zittel. Handbuch der Palæontologie, vol. i. Lief. 8, 1885, p. 568.

Fig. 9.—Length 3·7 (hinge-line 2·7), height 2·4 mm.

Valves like those of *Estheria minuta*, such as those shown by pl. i. fig. 29, and pl. v. figs. 8 and 9, "Monogr. Foss. Esth.," that have markedly straight backs, a more or less definite postero-dorsal angle, and strong concentric lines of growth (about 13 visible). Modifications produced by pressure, as well as by variable conditions of growth, make it difficult to find perfectly comparable specimens among fossil *Estheriæ*. The characteristic feature is the presence of numerous (about 20 or more) oblique striæ radiating from the middle region to the ventral and posterior borders. Posteriorly they produce a series of undulating wrinkles, crenulating the edge; but more forward they seem to have been little furrows formed by the notches in the edge of each successive overlapping lamina of the test, and giving a minute tile-like appearance to that part of the surface. A pattern somewhat like this, but on a still smaller scale, is visible in *Estheria tegulata* from the Scotch Coal-measures, to be published in the Trans. Geol. Soc. Glasgow, vol. ix. pl. v. fig. 6*b*.

In the *Estheriella* under notice the edge of each lamina is more or less thickened at and between the notches, and was there sufficiently produced as little hollow tubercles to leave the minute pits seen in the inside of the test (figs. 10 *a*, *b*). Here, also, there are traces of this structure reaching further up towards the umbo than on the outside (Fig. 9).

The specimens of both this and the next species are very delicate and scarcely ever perfect films of valves in bluish grey shale.

Some of the radials at their intersections of the lines of growth retain thin brownish relics of the test; but otherwise the valves are represented by partial moulds and casts, much flattened.

Both come from the Lower Buntersandstein of Dürrenberg, Saxony.

The specimens figured were courteously lent by the Director of the Geological Survey [1] at Berlin, at the instance of the late lamented Prof. Dr. Ch. E. Weiss, who also gave me some other specimens, collected by himself at Dürrenberg on the road to the Amtsberg, May, 1875.

6. ESTHERIELLA NODOCOSTATA (Giebel), 1857. Pl. II. Figs. 11, 13.

Posidonomya nodocostata, Giebel. Zeitsch. gesammt. Wissensch. Halle, 1857, p. 309, pl. ii. fig. 7.
Estheria ? nodocostata, Alberti. Ueberblick Trias, etc. 1864. p. 193, *note*.
Estheria (*Estheriella*) *lineata*, Weiss. Zeitsch. D. g. Gesellsch. vol. xxvi. 1875, p. 711, *note*.

Fig. 11.—Length 4·2 (hinge-line 2·7), height 2·5 mm.
Fig. 13. „ 3·5 („ 2·3), „ 2·4 mm.

Valves like those of the foregoing species, ovate-oblong in shape, with long, straight dorsal border; umbo quite forward; postero-dorsal angle usually pronounced; ends well rounded; the posterior curve larger than the anterior; ventral border gently curved. Concentric lines numerous and rather feeble. Radial riblets few (about 9), but much stronger than in *E. costata*, being definitely raised ridge-like wrinkles wide apart (Figs. 11 and 13). On the inside of the valve (Figs. 13 *a*, *b*) there is a little pit wherever the radial crosses a concentric stria, as if the edges of the successive laminæ of the test had been slightly raised just there, so as to leave a little hollow below. The specific name applied by Giebel to this form evidently has reference to this feature, as seen in Fig. 13 *a*. Locality and collection the same as mentioned with the foregoing species.

To make the history of the two foregoing species complete, the following extracts are taken from the published memoirs concerning them.

1857. Ch. G. Giebel, Palæont. Untersuchungen; Zeitschrift für die gesammten Naturwissenschaften, Halle, 1857, October u. November, Nos. x. xi. pp. 301-318.

Posidonomyæ [*Estheriæ*] in the Bunter Sandstone near Dürrenberg, p. 308, pl. ii. figs. 6 and 7.

P. Wengensis, p. 308, pl. ii. fig. 6. Gr. Münster, Beit. Petrefkd. iv. p. 23, pl. 16, fig. 12. Not far from *P. minuta*, but with fine radial lines from umbo to border. Wissmann has not noted this [?]; but it is conspicuous as a characteristic [none given in fig. 6; nor is the size mentioned]. [Some true *Posidonomyæ* are then compared.]

P. nodocostata, n. sp., p. 309 (fig. 7), as the other species may be

[1] Königl. geol. Landesanstalt und Bergakademie, Invaliden Str. 44, Berlin.

called, which occurs with *P. minuta* in two specimens from the depth of 612 feet in the bore-hole No. 3, near Dürrenberg, is long-oval in shape; $1\frac{1}{2}'''$ long, and not quite $1'''$ high; convex; rather smaller in front than behind; ventral border convex; the umbo distinct and rounded. There are seven radials (three of them in front, two in the middle, and one behind) reaching the border. An eighth appears to follow the hinge-line backwards. About sixteen regular, parallel, concentric lines cross the radials, and lose themselves in a series of roundish knots. The shell is very thin, of a dark horn-colour, quite like that of the associated *P. minuta*.

The relative size shown by Fig. 6 (about 2 mm., instead of 13 mm., $\frac{1}{2}$ inch), and the recognition of its alliance to and occurrence with *E. minuta*, make it probable that the *P. Wengensis* of Giebel is an *Estheria*, and different from the *P. Wengensis* of Wissmann, as intimated by von Alberti.

1864. Dr. F. von Alberti. Ueberblick über die Trias, etc., 1864. (See also Geol. Mag. 1878, p. 102.)

p. 192, *note.—Posidonomya Wengensis*, Giebel (not *P. Wengensis*, Wissmann, which is much larger), may be an *Estheria* near *E. minuta*, distinguished by weak radial lines.

p. 193, *note.—P. nodocostata*, Giebel; from 192 m. depth in bore-hole No. 3, near Dürrenberg; long-oval 0·003 m. long, and 0·002 m. high. Probably a crustacean.

P. minuta is a crustacean; so is probably *Posidonia Albertii*, Voltz, probably the same as *Posidonomya Germari*, Beyrich [Zeitsch. D. g. Ges. vol. ix. 1857, p. 377].

1875. E. Weiss. Zeitsch. D. g. Gesellsch. vol. xxvii. 1875, pp. 711, 712.

From the Lower Buntersandstein of Dürrenberg on the Saale, in Saxony, some small shells are described as being in size and condition like *Estheria Germari* of Beyrich, and occurring with it, but differing from it by having a certain number of riblets radiating from the umbo, and thus constituting a new type. It is remarked that Giebel had already described two species from Dürrenberg, with the names of *Posidonomya Wengensis* and *P. nodocostata*, which may perhaps be identical with the above mentioned. The two latter came from a boring; but the foregoing were found in the shales outcropping between the sandstone on the Saale, in the road above the Salt-works of Herr Director Metzner, and the bore-hole. When not well preserved, the valves lose their riblets near the umbo and on the front and hind borders; but these remain strongest and most distinct in the ventral region. In good specimens these two kinds of ribbing are readily recognized; one kind consisting of about 12 riblets, of which the middle 6–10, very sharply defined and wide apart, occur on the convex face, and are hollow on the inside of the valve, as furrows, proportionally distant with smooth spaces between, broken only by concentric wrinklings. This form may answer to *P. nodocostata*, Giebel, which, however, seems to have only 7 riblets.

The other species shows very numerous riblets, thickly set, more particularly towards the front and ventral borders; these are less sharp, and almost equal in breadth with the spaces between them. In particularly well-preserved specimens about 30 were counted, in others 20; but the number is difficult to determine; and we must recognize the difference of the two forms in the above-mentioned characters. This second species is evidently the *Wengensis* of Giebel. *Note* at p. 711.—Dr. E. Weiss named the first of the two foregoing species *Estheriella lineata*, and the latter *E. costata*; but he had a doubt about the naming, and thought that these names should be withdrawn until perfect proof of the difference between his and Giebel's species should be arrived at.

Dr. E. Weiss, though inclined to look on these two forms as belonging to a new genus, thought that it might suffice, with their great resemblance in general habit to *Estheria*, to place the radially-ribbed shells of Dürrenberg as a subgenus only, with the name *Estheriella*.

For the form with about 12 ledge-like riblets (*E. lineata*, Weiss, the *nodocostata* of Giebel), he gives—

	mm.	Proportion.
The height to the breadth (length) =	2·8 : 4·3	= 1 : 1·5
" " "	3·2 : 4·3	= 1 : 1·3
" " "	2·7 : 3·5	= 1 : 1·3

For the form with over 20 riblets and furrows (*E. costata*, Weiss, the *Wengensis* of Giebel),—

	mm.	Proportion.
The height to the breadth (length) =	2·5 : 3·8	= 1 : 1·5
" " "	2·4 : 3·5	= 1 : 1·4
" " "	2·3 : 3·3	= 1 : 1·4
" " "	2·2 : 3·1	= 1 : 1·4

Near Dürrenberg there are other horizons of *Estheria*. In the boring they are found at a depth of about 200 mètres; near the Royal Saltworks were found some very small *Estheriæ* (without riblets[1]), also on the left bank of the Saale, some feet below the first coarse white sandstones of the Middle Buntersandstein, at the cliff between Graslau and Leina, near Corbeth.

Note.—*E. nodocostata* (Giebel) retains its name, the form being recognized as that which Giebel figured and described in 1857. His *Wengensis*, however, is not the *Posidonomya* so named by Wissmann; nor is it from Wengen; and the name proposed by Weiss, namely, *costata* (though too near to *nodocostata* for convenience), should take its place.

In the "Mémoires du Comité Géologique," 4to. St. Petersburg, vol. vi. 1888, P. Kratow describes and figures two small bivalves with radial striæ as *Estheriella trapezoidalis*, pp. 469 and 557, pl. ii. fig. 27, and *E. oblonga*, pp. 470 and 557, pl. ii. fig. 28 (reaching

[1] Fig. 12 of Pl. II. may be one of these small *Estheriæ*, possibly *E. Germari*, Beyrich.

5 mm. in length), from the Permian beds of Tscherdyn on the Kolwa, on the western side of the Ural.

EXPLANATION OF PLATE II.

FIG. 1. *Estheria Andrewsii*, sp. nov. Left valve of the short form; magn. 4 diam.
„ 2. „ „ Right valve of the long form; magn. 4 diam.
„ 3. „ „ Portion of surface; magn. 50 diam.
„ 4. „ „ Another part of the surface, showing the inside of one layer, the impression of its outside on the matrix (dark); magn. 50 diam.
„ 5. *Estheria Hindei*, sp. nov. Left valve; magn. 6 diam.
„ 6. „ „ Portion of the beaded concentric striæ; magn. 50 diam.
„ 7. „ „ Portion of an interspace; magn. 50 diam.
„ 8. „ „ Portion of two interspaces; magn. 50 diam.
„ 9. *Estheriella costata*, Weiss. Right valve; magn. 10 diam.
„ 10. „ „ *a*, Part of the inside of a right valve; magn. 10 diam. *b*, Portion of the same; magn. 50 diam.
„ 11. *Estheriella nodocostata* (Giebel). Left valve; magn. 10 diam.
„ 12. *Estheria minuta* (Alberti). Possibly *E. Germari* (Beyrich); magn. 10 diam.
„ 13. *Estheriella nodocostata* (Giebel). *a*, Inside of left valve; magn. 10 diam. *b*, Portion of the same; magn. 50 diam.
„ 14. *Estheria minuta*, var. *Brodieana*, Jones. Left valve; magn. 5 diam.

II.—On the British Earthquakes of 1889.[1]

By Charles Davison, M.A.,
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I PROPOSE in this paper to write a short account of the earthquakes that have been felt in Great Britain during the year 1889, and to consider the relations of these earthquakes with the geological structure of the districts in which they occurred. The attempt seems to me worth making, for two reasons. The first is that, though few in number and slight in intensity, the earthquakes which visit this country are individually and in their connexion with preceding shocks, of considerable interest. And, secondly, the accounts, even when published, are widely dispersed, and, appearing chiefly in local newspapers, become difficult of access in after years. I believe, therefore, that an attempt to collect and discuss these scattered observations cannot be without some value.

I will, in the first place, describe the nature of the evidence on which these accounts are founded. For the two more important earthquakes, the chief authorities are the newspapers published within and near the disturbed areas. In a few cases, the notices they contain are far from satisfactory, and bear obvious signs of exaggeration.[2] But, in certain respects, their evidence seems to be trustworthy; and, as a general rule, I believe we may rely on them for a knowledge of the places where a shock was or was not felt, of the places where it was accompanied by the characteristic earthquake sounds, and also for a record of the effects of the shock sufficient to enable us to determine its intensity according to the Rossi-Forel scale.

[1] A paper read before the Royal Society, June 19, 1890, and published in abstract in the Roy. Soc. Proc. vol. 48, pp. 275–277.

[2] For example, the statement that, during the Edinburgh earthquake of Jan. 18, a boy was thrown out of bed at Gogar, is evidently inaccurate.

In many cases, however, this evidence has been supplemented by inquiries made in the several districts or by letters addressed to the local newspapers asking for further observations. The accounts I have thus received, being generally replies to a few definite leading questions, are often of considerable value; and I should like to take this opportunity of again thanking the ladies and gentlemen who have in this way rendered me such courteous and serviceable assistance.

In the description of each earthquake, the heading contains its name and date, the name being taken from that of the district principally affected by the shock. The time of occurrence is given in Greenwich mean time, the hours being numbered from 0 to 24. The intensity is determined by means of the Rossi-Forel scale, a translation of which is given below. This scale is very generally adopted by Italian and Swiss seismologists, and, though rough and undoubtedly variable to a slight extent, is well suited to the nature of the evidence at our disposal, the range of variability of any degree of the scale being probably less than the limits of error of ordinary observations.

Rossi-Forel Scale of Intensity.[1]

I. Recorded by a single seismograph, or by some seismographs of the same model, but not by several seismographs of different kinds; the shock felt by an experienced observer.

II. Recorded by seismographs of different kinds; felt by a small number of persons at rest

III. Felt by several persons at rest; strong enough for the duration or the direction to be appreciable.

IV. Felt by persons in motion; disturbance of moveable objects, doors, windows, cracking of ceilings.

V. Felt generally by every one; disturbance of furniture and beds, ringing of some bells.

VI. General awakening of those asleep; general ringing of bells, oscillation of chandeliers, stopping of clocks; visible disturbance of trees and shrubs. Some startled persons leave their dwellings.

VII. Overthrow of moveable objects, fall of plaster, ringing of church bells, general panic, without damage to buildings.

VIII. Fall of chimneys, cracks in the walls of buildings.

IX. Partial or total destruction of some buildings.

X. Great disasters, ruins, disturbance of strata, fissures in the earth's crust, rock-falls from mountains.

The disturbed area is defined as that at every point of which the earthquake-shock is felt. The form and position of its boundary must therefore depend on the practice of observers and on their power to detect a feeble shock; but, as a knowledge of this boundary can possess but little value when it does not represent an isoseismal line, I have endeavoured to draw it on the earthquake maps so as to pass as nearly as possible through places where the intensity was the same.

The epicentrum of an earthquake is the projection of the seismic focus or centrum on the surface of the earth. To determine its position, three methods have been proposed, depending respectively

[1] M. S. de Rossi. Bull. Vulc. ital., anno. iv. (1873), pp. 39–40; F. A. Forel, Arch. des Sc. phys. et nat., 3me pèr. t. xi. pp. 148–149.

on observations of the direction, intensity, and time of occurrence of the shock in different parts of the disturbed area; but the second method alone is applicable to the earthquakes here discussed. It will be seen, on reference to the maps which accompany this paper, that the isoseismal lines are approximately circles or ellipses of small eccentricity; and I have assumed that the epicentra coincide nearly with the centres of these areas. The correctness of the

Edinburgh Earthquake: January 18, 1839.

position so assigned to an epicentrum depends not only on the accuracy with which the isoseismal lines are traced, but also on a further assumption that their form is not greatly altered by variations in the nature of the rocks within the disturbed area. Also, if the seismic focus, as in the case of a fault, be inclined to the horizon, the intensity must, *cæteris paribus*, be greater on the side towards which the fault slopes; so that the epicentrum is probably nearer the

intersection of the focus with the earth's surface than would be indicated by the above method. Nevertheless, for the majority of British shocks, the assumption seems to me admissible, for the isoseismal lines in all the cases here considered are of small dimensions, and there is no evidence tending to prove any marked irregularity in their form. I believe that the true positions of the epicentra cannot differ by more than a mile (if by so much) from the positions indicated for the four principal earthquakes considered in this paper.

In two cases I have attempted to assign the origin of the earthquake to the impulsive friction along well-known and prominent faults. In each case, the evidence, being cumulative and far from abundant, is by itself certainly not conclusive; and the deductions made from it can only be regarded as at best but highly probable. Taken as a whole, however, the reasons for connecting the majority of non-volcanic earthquakes with such a cause are so weighty, and the theory is so comprehensive of apparently disconnected phenomena, that the inferences referred to are invested with a higher degree of probability than that with which they would otherwise and separately be endowed.[1]

The slow dying-out vibrations of very distant shocks are frequently propagated to this country, and are registered by magnetic and other recording instruments. More rarely are felt the perceptible vibrations of earthquakes that are less distant, but still extra-British, in their origin, *e.g.*, the earthquake of May 30, 1889, which disturbed the Channel Islands, the South of England, and the North of France. To include either kind of shock would unduly extend the limits of this paper, and I have therefore confined myself to the consideration of earthquakes whose epicentra are situated within the area of the British Islands.

Of these, there were at least five during the year 1889; namely, on Jan. 18 in the neighbourhood of Edinburgh; on Feb. 10 in Lancashire and parts of the adjoining counties; on May 22 on Ben Nevis; on July 15 in Kintyre, Gigha Island, and Arran; and on October 7 in the east of Cornwall. In addition to these, there were three others, the seismic origin of which is at present doubtful, or which rest on the evidence of one observer only.

1. Edinburgh Earthquakes: Jan. 18, 1889.

At least two shocks were felt at, and in the neighbourhood of, Edinburgh on this day, the first at about 4h. 10m., and the second at 6h. 53m. The time of occurrence of the former is variously given, but, as a rule so approximately, that it is very doubtful whether the existence of several separate shocks can be inferred. This may have been the case, but I do not think that the evidence is sufficient to prove that there was more than one shock preceding that which took place at 6h. 53m.

[1] It may be well to remark here, that, excepting the sections on the geological relations of the earthquakes, the following accounts were almost entirely written, the isoseismal lines were drawn upon the maps, and the positions of the epicentra determined, before any reference whatever was made to the geological maps of the disturbed areas.

First Shock.

Time of occurrence, about 4h. 10m.; Intensity, about V.

Very few observations were made on this shock, and I have only met with one detailed account, which I owe to the kindness of a correspondent in Edinburgh. It is impossible, therefore, to determine the boundary and extent of its disturbed area or the position of its epicentrum.

The only records I possess of this shock are from Edinburgh, Broomieknowe, Penicuik, and Bellsquarry; and these are all within, and several miles from, the boundary of the disturbed area of the second shock.

The recorded times of occurrence are: Edinburgh, about 2h., about 4h., and at 4h. 10m.; Broomieknowe, about 2h.; Penicuik, about 3h. and about 4h. 50m.; and Bellsquarry, at 5h. Most of these seem to be mere guesses. I have selected 4h. 10m. as probably the most correct time. It was obtained by reference to a clock almost immediately after the event, and was given to me by the correspondent mentioned above, who also estimated the time of the second shock as about 6h. 50m.

The intensity was probably about V.; but this estimate must be regarded as doubtful, as it is made from only one observation, and this at a place which may have been some distance from the epicentrum. At Edinburgh, my correspondent informs me, it was strong enough to make the bed rock: "the bed-room door shook, its handle rattled briskly and noisily and forcibly, and the glass above shook also."

A rumbling sound was heard at the time of the shock at Edinburgh; and at Broomieknowe a hollow noise was heard, but the shock itself is not recorded as having been felt there.

Second Shock.

Time of occurrence, 6h. 53m.; Intensity, VI.; Epicentrum, about 3 miles W. 42° S. of Balerno.

Disturbed Area.—The evidence for the study of this earthquake is much more abundant. I have altogether 93 independent observations, made at 53 different places. A large number, however, are from Edinburgh, and the rest, unfortunately, are not very evenly distributed over the disturbed area. On this account, the south-west portion of its boundary can only be drawn approximately.

An excellent account of the earthquake was given in the "Scotsman" for the following day, but in this attention was naturally directed chiefly to the places where the more striking phenomena were observed. With hardly an exception, the local newspapers fail to supplement this evidence as regards the limits of the disturbance; and I have therefore been obliged to rely principally on the accounts given to me by correspondents, and these, though of great value, are of course not numerous. With reference to the southern part of the area, however, the case is very different. For all the evidence from this part of the district, I am indebted to the

kindness and courtesy of Dr. C. B. Gunn, of Peebles who, at the cost of much time and trouble, sent me a report on the observations of the earthquake made in and near the north of Peeblesshire. I shall have occasion to refer again to this report, the value of which it would be difficult to over-estimate.

The outline of the disturbed area as drawn upon the accompanying map, is slightly elliptical in form. How far this outline may be considered as accurate will be partly evident from an inspection of the map, on which all places at which the shock was certainly felt are marked with small black discs, and those where there is good reason for believing that it was not felt with small crosses (+).[1] There can thus be little doubt about the form of the boundary from the neighbourhood of Polmont, by Dumfermline, Burntisland, Musselburgh, and Tynehead station, to Peebles; but, for the rest of the area, its course is less certain. I have made several inquiries in this part of the district, but entirely with negative results. From the intensity of the shock at the nearest places at which it was felt, I do not think, however, that the form of the boundary can differ very greatly from that laid down on the map, unless, owing to peculiar local conditions, the earth-vibrations were quenched more rapidly in the south-west quarter than elsewhere.

The disturbed area as thus defined is about 30 miles from north to south and 26½ miles from east to west, and contains an area (including the part occupied by the Firth of Forth) of about 830 square miles. Its boundary corresponds to an isoseismal line of intensity less than V., but decidedly greater than IV. The centre of the curve is about 3 miles W. 42° S. of Balerno.

It is worthy of notice that in Edinburgh, where the intensity was V., the shock was not felt by any one on the Castle Hill, nor at the Observatory on Calton Hill. The geological structure of the district may also account for the shock not having been felt at Inchkeith, and not having been recorded as felt within a large part of the area occupied by the Pentland Hills.

Time of Occurrence.—Omitting all confessedly approximate determinations of the time of occurrence, the following definite records have been made: Edinburgh, 6h. 50m., 6h. 52m., and 6h. 54m. or 6h. 55m.; Penicuik, 6h. 52m.; Leith, 6h. 53m. 15s. ± 10s.; Trinity (near Leith), 6h. 54m. ± ½m.; Harperrigg and Peebles, 6h. 55m. These estimates, with one exception, are not exact enough to be used for ascertaining the velocity of the earth-wave or the position of the focus. Probably the most correct of these times is that given for Leith; it was determined by Mr. G. Redpath. "I immediately turned round," he says, "and noted the time, which I found was 53 minutes 15 seconds past six by a clock in my sitting-room. On going to verify it by an astronomical clock in another room, I found to my regret that I would have to allow a margin of about ten seconds—earlier or later." This is sufficient, however,

[1] To the south of Peebles, owing to the small scale of the map, I have been obliged to omit the indication of a number of places where, as Dr. Gunn's inquiries show, the shock was not felt.

to determine the *epoch* of the shock. I have given it as 6h. 53m., but, as Leith is about 12 miles from the epicentrum, it may have been a few seconds earlier.

Nature of the Shock.—For descriptions of the nature of the shock, I have to rely chiefly on newspaper accounts, and these, as a rule, are far from being either exact or detailed.

In most parts of the disturbed area, it would seem that the shock was noticed as a single oscillation, the observers in some cases feeling as if the bed or chair on which they rested were slightly raised and then lowered. A few compare the sensation to that of passing over a wave in a small boat.

From at least five places, however, there come accounts of a second oscillation immediately following the first; as if there were two prominent vibrations, while the commencing and concluding tremors were generally imperceptible. These places are Edinburgh, Leith, Ratho, Balerno, and Peebles. But it should be noted that all observers at these places did not detect the second oscillation; and this was probably owing to the latter being, as one observer at Edinburgh states, slighter than the first. At Balerno, again, it was remarked that, though both movements were momentary, the second was the more lasting of the two.

There is only one other noteworthy point that I can gather from the somewhat scanty descriptions. In all the instances, but one, in which the character of the movement is recorded, the oscillation is described as a rise of the ground, followed by a fall. This is the case at Edinburgh, Balerno, Trinity (near Leith), Davidson's Mains, Linlithgow, and Polmont. On the other hand, at Penicuik, a "workman, who happened at the moment to be seated, felt the brick floor recede from his feet, and then, as it were, return to them." Now, the six places just mentioned are in the northern part of the disturbed area; whilst Penicuik is a short distance to the east of the epicentrum. I shall recur to this point in discussing the origin of the earthquake.

Duration.—Records of the duration come from seven places, and range from not greater than one second (at Davidson's Mains), to about two seconds (at Edinburgh, Trinity, Leith, and Penicuik), and about three seconds (at Balerno and Kirknewton). Probably some of the estimates of the duration also include that of the sound-phenomena; but, in either case, they seem to indicate a decrease in duration as the disturbance radiated from the origin.

Intensity.—The following list gives the intensity of the shock at places where the accounts were sufficiently detailed for its determination.

VI. Balerno, Currie, Harperrigg.

V. Bellsquarry, Corstorphine, Davidson's Mains, Eddlestone, Edinburgh, Gogar, Hartwood, Juniper Green, Kirknewton, Leith, Linlithgow, Penicuik, Ratho.

IV. or V. Bathgate, Polmont.

IV. Burntisland, Causewayend, Cockburn, Dumfermline, Eskbank, Peebles.

These observations are not sufficiently numerous to enable isoseismal lines to be drawn with any accuracy. But it is evident that the isoseismal of intensity V. could not be very distant from the boundary of the disturbed area, as drawn upon the map. We may therefore conclude that this boundary corresponds to an isoseismal of intensity between IV. and V., and probably nearer V. than IV.

Sound-phenomena.—All the places where the characteristic earthquake-sounds are known to have been heard are marked on the map with a small cross (+) through the spot indicating the position of the place. They are unfortunately very few in number, only 19 out of the 53 places from which records have been received. But, on the other hand, there are several places where the shock was felt, and where it is expressly stated that no sound was heard. These are Leith, Trinity, Burntisland, and Polmont, and they are indicated on the map by a stroke (—) drawn through the spot representing the place. It is also important to note that, whilst records from Edinburgh (where the intensity was V.) are numerous, 28 in number, in only two cases is there any mention made of earthquake-sounds. Again, at Peebles (where the intensity was IV.) out of four separate accounts which Dr. Gunn sent me, two are records of the sound-phenomena only, the shock being apparently not felt in these cases. From these facts, two conclusions may be drawn:

(1.) The area throughout which the sounds were heard was not coextensive with the disturbed area; a fact previously noticed in the case of other earthquakes.

(2.) The centre of the sound-area was not coincident with that of the disturbed area, but lay probably about $2\frac{1}{2}$ miles to the south or south-east of the latter. It will be seen that a similar inference may be made in the case of the Lancashire earthquake of Feb. 10. I believe that this conclusion is new, and will be found to throw light on the origin of earthquake-sounds.

In their character the sounds accompanying the Edinburgh earthquake do not seem to have been in any way unusual. The following are the only detailed descriptions I possess:

Balerno: like the falling of a heavy mattrass.

Bathgate: as if a heavy waggon had passed along the street.

Cockburn: as though a large tree had fallen near the house.

Edinburgh: (1) like the rumbling of a passing coach; (2) a loud sharp crash, as if the door had been slammed in an extraordinary manner.

Harperrigg: like the firing of a time-gun twice, accompanied with an oscillation.

Kirknewton: a loud clanking noise.

Linlithgow: a suppressed rumbling sound.

Peebles: like the passing of a heavy cart.

Ratho: like the passing of a heavy traction-engine.

In every place the duration of the sound seems to have been very short. This is evident from some of the above accounts, and probably, as before remarked, the duration of the sound is included in the estimates of the duration of the shock given above. The

sound is generally said to have accompanied the shock, but this is a vague expression. Probably it overlapped the shock slightly at either end; at different places in and near Peebles, Dr. Gunn informs me that it was said in one case to precede the shock, in two to follow it, and in one to both precede and follow it.

Position of the Seismic Focus and Geological Relations.—The faults of the Edinburgh district "group themselves naturally into two series, one more or less at right angles to the strike of the beds, that is, east and west, or from south-east to north-west; the other usually of greater magnitude, in long parallel north-east and south-west lines." The latter faults "lie almost wholly along the axis of the Pentlands. In place of cutting across the strike of the country as the other faults do, they run parallel to it. Flanking each side of the anticline, their effect has been to depress the Carboniferous strata against the older rocks of the hills, so that on the west side their downthrow is to the west, and on the east side to the east." Of these main faults, which are four in number, three are shown on the accompanying map of the Edinburgh earthquake. The first of these (marked AA on the map) extends from the sea at Portobello to beyond Carlops in Peeblesshire; its downthrow is to the south-east, and the amount of the throw in parts probably not less than 3000 feet. The second fault (BB) reaches from the head of the Logan valley to North Black Hill, where it seems to die out. The third fault (CC) extends in a wavy line from Arthur's Seat, near Edinburgh, to the neighbourhood of Bevelaw; but in certain parts its course is somewhat doubtful. The downthrow of the two latter faults is to the north-west, but the amounts of their throw are unknown.[1]

Now, the centre of the disturbed area, as indicated on the map, lies about 3 miles W. 42° S. of Balerno; and this, as before remarked, may be regarded as the approximate position of the epicentrum, which is therefore to the north-west of all three of the faults. The earthquake cannot, then, have any connexion with the first of these faults. From the line of the third fault (CC), the perpendicular distance of the epicentrum is about $1\frac{1}{2}$ miles. The shock might apparently have been caused by a slight extension of the fault towards the south-west, or by a slip of the fault, supposing it to extend underground far enough in this direction. But, unless we assume that the earthquake originated at one fault, and the earthquake-sounds at exactly the same moment at another, it does not seem possible to connect the earthquake with this fault; for the centre of the sound-area lies about two or three miles to the south or south-east of the epicentrum, and therefore to the south or south-east of the line of fault at the surface.

Turning next to the second fault (BB), we find the perpendicular distance of the epicentrum from the line of fault at the surface is about $2\frac{1}{2}$ miles; and this would admit of the sound-focus being on the fault-plane, but probably close to the surface. It does not seem

[1] H. H. Howell and A. Geikie, Geology of the Neighbourhood of Edinburgh, pp. 118–119.

unreasonable to infer, then, that the Edinburgh earthquake was in some way connected with this fault.

If the inclination of the fault were known in the neighbourhood of the epicentrum, this would enable us to determine approximately the depth of the seismic focus, assuming the inclination to be constant to a depth of a few miles below the surface. The exact inclination is, however, unknown; but Prof. J. Geikie informs me that it "cannot be less than 70°–80° from the horizontal, say, about 15° from the vertical." If this be the case, then, the depth of the centre of the seismic focus is not much less than 6 miles, nor much greater than $12\frac{3}{4}$ miles, and perhaps does not differ considerably from $8\frac{1}{2}$ miles.

The bearing of the observations made on the first direction of motion of the principal vibration will now be obvious. The six places (Edinburgh, Balerno, Trinity, Davidson's Mains, Linlithgow, and Polmont) where the movement was first upward, lie on the downthrow side of the fault, whilst Penicuik, where the movement was downward first, is on the upthrow side. Now, if the mass of rock on the downthrow side slipped slightly downwards, or if the mass on the upthrow side slipped upwards, the particles on the downthrow rock-face would be drawn upwards first, and those on the upthrow rock-face would be drawn downwards. The earth-wave or the rock-masses on either side of the fault would thus start in opposite phases of vibration, and the resulting effects at the seven places on the surface would be those described above.

I believe we may, then, with some probability, conclude: (1) that the Edinburgh earthquake was caused by a slip of the fault marked BB on the map, at a spot vertically below the position indicated for the epicentrum, and therefore not far from the middle of the fault, where, probably, the throw is a maximum and where earthquake-action has been most frequent or most intense; (2) that, on account of the simple character and short duration of the disturbance, the horizontal length of the fault over which the slip took place was very short, possibly less than a mile; (3) that the slip of the downthrow side was downwards or that of the upthrow side upwards, resulting, in either case, in an increase of the throw of the fault in the neighbourhood of the seismic focus; and (4) that, while the region of maximum slip, the focus of the earthquake proper, was probably at a depth of several (perhaps about 8) miles, the slip extended upwards to within a short distance of the surface, this part of the slip-area being the focus of the sound-vibrations. This latter conclusion will be considered somewhat more fully in treating of the Lancashire earthquake, and at greater length in a subsequent paper.

"When we reflect," says Dr. A. Geikie, "upon the extent of depression produced by these faults, we see at once that the Carboniferous rocks must formerly have stretched across the area of the Pentland Hills, and that it is to the agency of these dislocations,

[1] On the Existence of Undisturbed Spots in Earthquake-shaken Areas, Geol. Mag. (April, 1886), Vol. III. pp. 157–159.

aided subsequently by an extensive denudation, that the older rocks of that chain are visible."[1] The Pentland faults have thus played an important part in the past history of the district. But their work is not yet finished, and the occurrence of the Edinburgh earthquake shows that the process of geological change is still being carried out on the same lines as before. It remains for future earthquakes to enable us to determine the laws which govern these changes and the rate at which they are now taking place.

Authorities.—"Dalkeith Advertiser," Jan. 24; "Dumfermline Journal," Jan. 26; "Falkirk Herald," Jan. 19; "Lanarkshire Examiner," Jan. 26; "Peeblesshire Advertiser," Jan. 26; "Scotsman" (Edinburgh), Jan. 19, 21, 22, 23, 25, and Dec. 28; "West Lothian Courier" (Bathgate), Jan. 19 and 26.[2]

For other information contained in the above account, I have pleasure in thanking the following gentlemen: Mr. J. Aitken, F.R.S., Prof. R. Copeland, F.R.S.E., Dr. G. Craigie (Musselburgh), Mr. W. Dick (Tynehead Station), Dr. John Doig (Bathgate), Prof. J. Geikie, F.R.S., Dr. C. B. Gunn (Peebles), and the Rev. W. Ross (Polmont).

(*To be continued.*)

III.—An Inexpensive Apparatus for the Isolation of Minerals by Means of Heavy Liquids.[3]

By J. W. Evans, LL.B., B.Sc., F.G.S.;
Demonstrator in Geology, Royal College of Science, London.

I AM aware that in describing a new apparatus for separation by heavy liquids, I am adding another item to a list which is already a very long one. My only excuse is that this particular form has the advantage of being easily and cheaply constructed from ordinary chemical apparatus, and yet has most of the advantages of Thoulet's[4] comparatively expensive form.

The construction and use will be best explained by means of the accompanying drawings.

A is a cylindrical funnel. The conical portion connecting the upper cylinder with the narrower cylinder or tube below, should be as steep as possible, otherwise a little trouble is occasioned by particles adhering there.

The funnel is closed below by means of a piece of india-rubber tubing and pinchcock. It may be supported on an ordinary wooden filter stand.

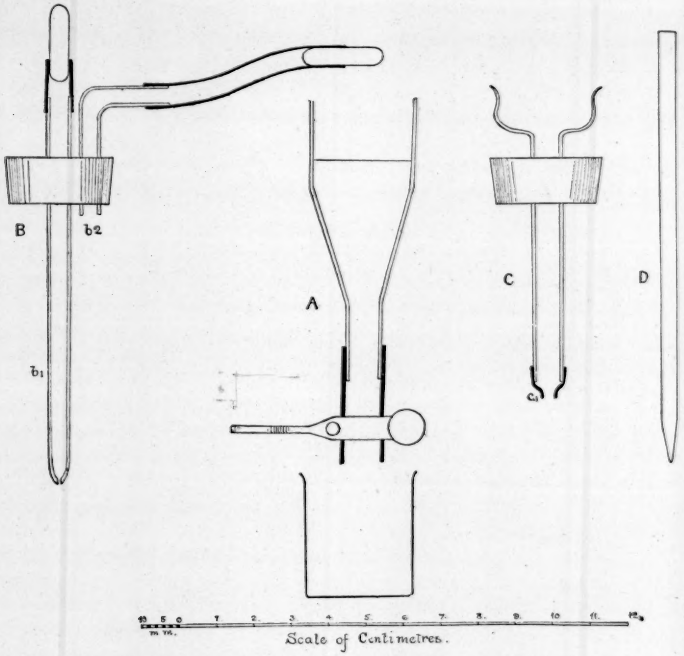
[1] Geol. of the Neighbourhood of Edinburgh, p. 120.

[2] The following papers contain descriptions of the Edinburgh earthquake:—A. G., The Earthquake at Edinburgh, Nature (Jan. 31, 1889), vol. 39, pp. 324-325. R. Richardson, On the Earthquake Shocks experienced in the Edinburgh District on Friday, January 18, 1889 (read before the Edinburgh Geol. Soc. on Feb. 21, 1889), "Scottish Geographical Magazine" for March, 1889.

[3] A short notice of my apparatus in its simplest form will be found at p. 108 of the interesting and valuable Manual by Professor Cole, of the Royal College of Science, Dublin, entitled, "Aids to Practical Geology," which has just been published.

[4] Bull. Soc. Min. de France, t. ii. (1879) p. 17.

B represents a long glass tube (b_1) passing through the centre of a cork. At the lower end the tube is brought to a blunt point, in which is a minute aperture. After being drawn out to a point, the end must be carefully heated again so as to thicken the glass round the hole without closing it entirely. Unless this is done, the point of the tube is apt to break off. This tube can be closed above by india-rubber tubing and a short piece of glass rod. The cork is also perforated (as shown) by another tube (b_2), which can be closed in a similar manner.



The liquid and the material to be operated on are placed in the funnel. When the first separation has taken place, the apparatus *B* is inserted, the point of b_1 should reach down close to the pinchcock. b_1 is left open at the top, and b_2 is connected with an air-pump, which should be very cautiously worked and the pressure diminished so that a gentle stream of bubbles passes from the opening at the end of b_1. The particles are thus thoroughly shaken; the lighter fragments that have been carried with the heavier, or *vice versâ*, are disengaged.

The upper end of b_1 is now closed and the air is exhausted so as to get rid of any air attached to the grains. The apparatus may then be separated from the air-pump by compressing the india-rubber tube attached to b_2 and at the same time disconnecting the

end and inserting the piece of glass rod. After the lapse of some time air is re-admitted through b_2.

The above processes may be repeated several times, if thought necessary; to more thoroughly shake the lighter fragments, the tube b_1 may be raised till the end is only just below the liquid.

If an air-pump is not available, the air may be withdrawn by the lungs, but the effort to overcome the weight of the column of liquid is apt to render the passage of air rather violent. The tube b_1 may also be used (without the cork) to agitate the lighter layer by gently blowing just below the surface; or to disturb any fragments resting on the conical part of the apparatus, which may be best done by drawing up a portion of the liquid and then letting it descend from the tube close to the fragments to be moved; but it is safer to use a pipette for this purpose.

A few lighter particles may adhere to the tube as it is removed; if it is desired not to neglect these, they may be washed back by liquid of the same density.

In order to draw off the heavier particles, the apparatus *C* and *D* is used. *C* is a thistle-tube perforating a cork, and having at the lower end a piece of india-rubber tube (c_1) of less diameter when unstretched than *C*. The india-rubber at the end of *C* fits tightly into the top of the narrow portion of *A*. *D* is a glass rod brought to a conical point at the lower end. Insert it in *C* so that the end projects some distance beyond the india-rubber c_1, in which it should fit tightly. The whole is then inserted in the funnel. If this is done skilfully, few (if any) of the lighter particles are carried down with it, as the conical end of the glass rod causes a centrifugal movement at the surface as it passes down. To remove any that may have descended, adjust the cork so that the india-rubber is a little above the narrow portion of the funnel; a little movement and the lapse of a few minutes will be sufficient. If any particles are caught by the lower end of the india-rubber c_1, they may be displaced by an up-and-down movement of the rod *D* relatively to *C*. Now depress *C* so as to fit tightly in the narrow portion of the funnel, tighten the cork, withdraw the rod *D*, and open the pinch-cock; the lower part of the liquid falls with the heavier fragments into a beaker; the tube is then thoroughly washed clear of all residuary particles by a stream of distilled water poured into the cup of the thistle-tube *C*.

After letting the tube drain till nearly free from water, the pinch-cock having been closed, and the tube *C* removed, the density may be lowered for another separation; this is best done by gradually adding the diluting fluid through b_1 or a similar tube, the small aperture being at the bottom of the narrow portion of the funnel. The thin stream of lighter fluid easily mixes with the heavier as it rises, especially if the tube is being gently agitated.[1]

[1] I have not arranged for the calculation of density from the volumes used. If required, the apparatus could be graduated (being heightened if necessary). Practically it is better to dilute with a solution only slightly lighter till separation takes place and then determine the density by one of the usual methods.

The above form is adapted for use with Klein's solution (Borotungstate of Cadmium), which has been found the best for practical use for densities below 3·28, as it has not the highly poisonous character of the Sonstadt solution (potassium iodide and mercuric iodide) and does not decompose and discolour so easily as methylene iodide. Above 3·28, methylene iodide, with or without the addition of iodoform (as proposed by Retgers),[1] must be used. Here, as the use of india-rubber is inadmissible, the pinchcock must be replaced by a glass tap (but the bore need not be the same as that of the glass tube, as is usually necessary in apparatus of this nature); and instead of using the india-rubber c_1, the end of the thistle-tube C and the base of the conical part of the funnel must be ground so as to fit one another, and the rod D must closely fit the tube.

The tube C has some external similarity to the plug used in the useful apparatus devised by Mr. Smeeth;[2] but there the plug is not perforated, and there is no resemblance in the mode of action of the two forms.

I ought to add that all my work with heavy liquids has been carried on at the Royal College of Science, where Professor Judd has kindly given me every facility in my endeavours to find the best practical form of instrument neither too expensive nor too delicate for students' work.

IV.—Essays in Theoretical Geology.

By R. D. Oldham, A.R.S.M., F.G.S.,
of the Geological Survey of India.

The Age and Origin of the Himalayas, with Especial Reference to the Rev. O. Fisher's Theory of Mountain Formation.

The Facts (*continued from p.* 18).

I HAVE already shown that the northern boundary of the Indo-Gangetic alluvium is a structural one, and that the rock area immediately to the north of it has been elevated, while the nature of the boundary on the south, the deep imbayments of the alluvium, the gentle manner in which the older rocks slip under it, and the inliers, alike show that, on the south, the alluvium has gradually encroached on the rock area by the subsidence of the latter.

I have also shown that at one period the present demarcation of the Peninsular and Extrapeninsular areas did not exist, and that the latter extended across the area now occupied by the Gangetic alluvium into what is now Sikkim. From this we may conclude that during the rise of the Himalayas the formation of the depression now occupied by the alluvial deposits of the Indus and Ganges has proceeded, and that, just as its northern boundary has been encroached upon by the gradual southward extension of the Himalayan region, so it has itself encroached on the rock area to the south, and necessarily at a greater rate.

[1] J. W. Retgers, Neues Jahrbuch, 1889 (2), p. 185.

[2] Scientific Proceedings of the Royal Dublin Society, vol. vi. (new series 1888), p. 58.

If this hypothesis is true, the sections of deep borings near either limit of the alluvium should show diverse results as to the relative proportion of fine to coarse-grained deposits near the surface and further down. On the north, the southward march of the edge of the hills would lead to coarse-grained deposits extending over finer, while near the southern margin the increasing distance from the edge of the rock area should lead to fine-grained deposits being laid down over coarser.

The deep borings, which have been put down in the Gangetic alluvium, are few in number, and, except two, are not well situated for testing the hypothesis.

The first of these is the boring made in Fort William, Calcutta, in 1836-38. In discussing this and the other borings I shall adopt the method of classifying the beds passed through as "sand" and "clay." A more perfect classification is impossible, owing to the vagaries of nomenclature indulged in by the men, never trained geologists, to whom the sinking of the borings must necessarily be entrusted. By classifying "sand," "coarse sand," "clayey sand," etc., as sand; and "clay," "silt," "sandy silt," "limey silt," etc., as clays, we shall get a very fair general idea of the relative coarseness of grain of the beds passed through in different parts of the same boring.

Adopting this system of classification, we may make an abstract of the Fort William boring[1] thus:—

ft.		ft.	sand	clay
0	to	100	0	100
100	,,	200	11	89
200	,,	300	95	5
300	,,	400	98	2
400	,,	481	81	0

The increase in coarseness of grain of the beds passed through is conspicuous enough in this abstract, but the reality is even more striking, for, in the sand from 180 feet downwards, some beds of gravel and pebbly sand are included, and the boring was finally brought to a standstill in a bed of gravel which it was not found possible to penetrate.

The second boring of importance is that made at Umballa.[2] Adopting the same broad classification of clay and sand, we get the following result:—

ft.		ft.	sand	clay	
0	to	100	59	37	soil 4
100	,,	200	56	42	kunkur 2
200	,,	300	58	42	
300	,,	400	54	46	
400	,,	500	46	54	
500	,,	600	37	63	
600	,,	701	6	95	

Here we have, as the hypothesis requires, a very distinct increase

[1] For detailed section see Rec. Geol. Surv. Ind. vol. xiv. p. 221 (1881); Calc. Journ. Nat. Hist. vol. i. p. 324 (1841).

[2] Rec. Geol. Surv. Ind. vol. xiv. p. 233.

in coarseness of texture in the upper beds as compared with the lower.[1]

Besides these two borings, one has been put down at Agra, the evidence of which is slightly vitiated by the peculiar local conditions. The abstract of the section is as follows:[2]—

ft.		ft.	sand	clay	kunkur
0	to	100	65	35	0
100	„	200	44	56	0
200	„	300	0	97½	2½
300	„	400	18	76½	5½
400	„	481	7	74	0

Here there would seem to be an increase of coarseness of texture, both upwards and downwards, from 200 feet. The explanation of this, I apprehend, is to be found in the fact that the surface deposits round Agra are largely composed of blown sand; and it is probable that the sand beds found in the uppermost 160 feet of the section are of æolian origin, while below that the beds are alluvial and exhibit the gradual upward increase in fineness of texture required by the hypothesis.

A fourth boring has lately been sunk to a depth of 1336 feet at Lucknow. As might be expected from its situation, "there is no marked increase or decrease in the coarseness of the beds passed through; but, near the bottom of the boring, some beds of coarse sand were found, and these may indicate an approach to the base of the alluvium and mark a time when its southern boundary was not far from Lucknow."

To sum up, of the four deep borings which have been made, two are completely in accordance with the hypothesis; one is in favour of it, though its evidence is vitiated by peculiar local conditions; while the fourth is so situated as to give no evidence one way or the other till it is carried to a greater depth. Stronger proof is at present impossible, and we may accept the hypothesis as a true one.

To summarize the history of the Himalayas as revealed by their geology, we find that at the commencement of the Secondary period the Himalayan system of disturbance had not commenced; that, some time towards the end of the Secondary period, it originated near the middle of the range and gradually extended outwards, reaching the country now accessible to observation in the North-western portion of the Himalayas, about the commencement of the Tertiary period; that the beds had, at this epoch, undergone but

[1] On a former occasion (Rec. Geol. Surv. Ind. vol. xviii. p. 118) I was misunderstood when urging this argument; it was pointed out that Umballa is peculiarly situated in an area which receives no coarse deposit; that, at an equal distance from the foot of the hills, large boulders were found in the foundations of the railway bridge over the Jumna; and it was urged that the section was consequently irrelevant. Owing to this I must here point out that the argument is by no means affected by the greater or less average coarseness of texture of the deposits on other sections, as it only claims that on any individual section near the northern limit of the plains the beds near the surface will, on the average, have a greater coarseness of texture than those which underlie them.

[2] For detailed section see Rec. Geol. Surv. Ind. vol. xviii. p. 121.

little disturbance and contortion, while such compression as they had been subject to did not belong to the Himalayan system of disturbance. From this time onwards the beds have been continuously subject to compression, contortion, disturbance and elevation, and the Himalayas have been continuously an area of denudation.

As soon as the Himalayas were defined as a distinct hill range, a series of subaerial deposits of great thickness began to be deposited in a region of subsidence along their outer edge, and the demarcation between the areas of subsidence and deposition on the one hand, and of elevation and denudation on the other, was abrupt, exhibiting itself at the present day as a gigantic fault. As the Himalayas rose, the boundary between the two areas advanced step by step to the southwards; the beds which had been deposited along the foot of the original hills were compressed, disturbed, elevated, and, consequently, exposed to denudation; but the new limit between the area of elevation and of depression was again an abrupt one, which, on a subsequent further advance of the hill area, showed itself as a fault with an upthrow towards the central range. Concurrently with this southward march of the margin of the Himalayas, the depression occupied by the Indo-Gangetic alluvium extended itself to the southwards by the gradual subsidence of the peninsular rock area.

Such are the main features of the history of the Himalaya. As I have shown, there have probably been minor elevations of the range unaccompanied by disturbance; but, in the main, its elevation is the direct result of, and has been accompanied by, compression and contortion of the beds of which it is composed.

II.—*The Theory.*

It is now generally admitted that the elevation of what may be called true mountain ranges is but a secondary effect of that compression which their structure shows they have undergone. There is also a general concensus of opinion in favour of the Herschel-Babbage doctrine that denudation and elevation, deposition and subsidence, are closely connected with each other, at least in so far that denudation acts in intensifying the effect of the causes which lead to elevation, and deposition of those that lead to subsidence.

The most recent and complete adaptation of this doctrine to the theory of mountain formation is contained in the Rev. O. Fisher's work on the "Physics of the Earth's Crust." Mr. Fisher's hypothesis demands a solid crust resting on a denser magma, whose condition is actullay or virtually that of a fluid. The crust, on being subjected to compression, yields along certain lines and as a result is thickened, both upwards and downwards, from a zone somewhere in the thickness of the crust "above which the material will on the average be sheared upwards, and below it downwards;" this zone is called the "neutral zone," and, for reasons which it is needless to enter into here, is placed at three-fifths of the thickness of the crust from its upper surface.[1]

As, for many reasons, it is highly improbable that the elevation

[1] Physics of the Earth's Crust, second edition, pp. 183–184.

would be perfectly symmetrical, we may assume that the watershed would be nearer one side than the other, and, consequently, a larger amount of debris removed by denudation would be deposited on the opposite side of the ridge, with the result that the centre of gravity would be shifted towards that side on which the greater quantity of sediment is deposited, that is, to the right of the diagram, Fig. 1. In this state the centres of gravity and of flotation, are no longer in the same vertical, and equilibrium is only restored by a rotation of the disturbed tract accompanied by an extension of the depression to the right and a diminution and ultimate extinction of that to the left. Along with this rotation there would be a general shifting of the tract to the right, which would expose the left-hand side to tension, "which may possibly open fissures downwards on the western side of the range."

Fig. 2.

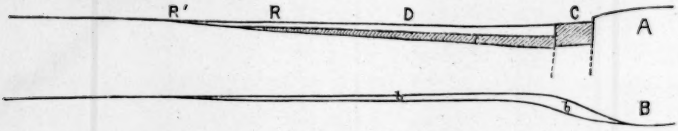


Fig. 1.

Fig. 1.—Fisher's Physics of the Earth's Crust. Diagram on p. 186. 2nd edition.

Fig. 2.—Diagram to illustrate the theory of the elevation of the Himalayas. scale: hor. about 60 miles, vert. about 30 miles to 1 inch.

A.—Massif of the Himalayas.

B.—"Root" of the same.

C.—Earlier marginal deposits, compressed and elevated.

c.—Continuation of the same, depressed and undisturbed.

D.—Subsequent deposits overlapping C.

b.—Sinking of lower surface of crust due to C and D.

The extinction of the Nummulitic sea of the central Himalayas and the great volcanic outbursts which accompanied it may represent the extinction of the depression on the left-hand side of the diagram, but the greater part of the elevation of the Himalayas having taken place since this, we are at once encountered by the difficulty that the hypothesis requires a rotation of the whole of the Central Asian plateau. We have no reason to suppose that so large a mass of the earth's crust would have a rigidity sufficient to allow of its rotation as a whole; on the contrary, there is every reason to suppose that it would yield infinitely to any long continued stress. In Mr. Fisher's investigation it is, however, assumed that all lateral pressure is relieved before the action of denudation commences. Such a simplification of the conditions is essential to a mathematical investigation; but as in the case of the Himalayas the compression has lasted up to the recent period, while there are not wanting indications that it is still in progress, we may take it that the state of things which the latter part of Mr. Fisher's investigation deals with has not yet been reached, and we may consequently neglect all considerations connected with the rotation of the Himalayan tract of elevation.

We have now to consider what modifications are required to fit the purely mathematical theory to the more complex conditions of actuality. In the first place the elements of rigidity and rotation being abandoned, we need not consider the left-hand side of the diagram, and may redraw it in greater accordance with the conditions of the Himalayan region. (See Fig. 2.) We have now an elevated region *A A* subjected to denudation, and adjoining it an area extending to *R*, on which deposition is taking place, the deposits being contributed by the elevated ground *A* to the north, and the waste of the rock area to the south. The tract being supposed to be in equilibrium, as *A* is lightened by denudation, the surplus floating power of B will cause it to rise, and the load thrown on *D* will cause it to sink, especially in the neighbourhood of *A*, where the load is greatest, till the magma displaced by the lower surface of the crust is sufficient to float the load. The result will be, firstly an extension of the depression in a direction away from the elevated tract *A*, and secondly a strong tendency to either fracture or flexure of the crust at the junction of *A* and *D*.

As we may take the crust to be infinitely yielding to long-continued stresses, there is no reason why that produced by the lightening of the one area and the loading of the other should not be relieved simply by the sinking of the latter and the rising of the former on either side of a separating plane. But denudation and deposition are not the only forces at work; for, to bring the case into connection with that of the Himalayas, we must suppose compression to be continually at work. This will be relieved partly by an additional elevation of *A*, but also by the compression and consequent elevation of the marginal deposits of *D*, which would not offer the same resistance as the already consolidated beds of *A*. In this way the deposits on the edge of the depression *D* would gradually come to form part of the tract *A*, whose boundary would advance towards *R*, but not to the same extent as the shifting of the outer boundary of the depression towards *R'*.

This must not be regarded as a modification, but rather as an amplification of Mr. Fisher's theory; it is a more detailed investigation of a part of the process which does not lend itself to mathematical treatment. The elevation of the marginal deposits of the depression is of a different nature to that referred to by Mr. Fisher, an elevation which belongs to the period of decadence of the range, and is unaccompanied by disturbance. The Himalayas have only just completed their growth, if they are not still growing, and the elevated marginal deposits with which we have to deal owe their elevation to compression, and belong to the period of growth of the range.

Taking this amplification of the theory, we find that a mountain range which has completed or nearly completed its growth, but not entered on the period of its decadence, should show the following features:—

I. There should be a region continuously exposed to denudation and simultaneously to elevation.

II. Coterminous with this there should be an area where deposition and subsidence are simultaneously taking place.

III. The area of deposition and subsidence should gradually spread outwards from the mountain range.

IV. The region of denudation and elevation should gradually encroach on that of deposition and subsidence.

V. The demarcation between the areas of elevation and of subsidence should be abrupt.

VI. Near the limit the submontane deposits should, during the elevation of the range, be raised with the accompaniment of disturbance.

VII. It is improbable that the system of disturbance would commence simultaneously along its whole length, but rather it would extend longitudinally as well as laterally.

It is only necessary to compare this statement of the deductions arrived at theoretically with the results of observation as given in the first part of the paper, to see how close and complete is their accordance. And in this agreement we find very strong evidence of the truth of the theory.

I have avoided overburdening the text with references; none of the facts are here published for the first time, and but little of the deductions. The ideas and conclusions relative to the history of the Himalayas are well known to those who have worked at it; in a more or less complete form they have been published at different times, but have never before been collected together. The following papers have been made use of, and should be consulted for further details:—

Sir P. T. Cautley. On the Structure of the Sewalik Hills and the Organic Remains found in them. Geol. Trans. second series, vol. v. pp. 267–278 (1840).

H. B. Medlicott. On the Geological Structure and Relations of the Southern Portions of the Himalayan Ranges between the Rivers Ganges and Ravee. Mem. Geol. Surv. Ind. vol. iii. part 2 (1863).

F. Stoliczka. Summary of Geological Observations during a Visit to the Provinces of Rupshu, Karnag, South Ladak, Zanskar, Suroo, and Dras of Western Tibet, in 1865. Mem. Geol. Surv. Ind. vol. v. pp. 337–354 (1866).

A. B. Wynne. Observations on some Features in the Physical Geology of the Outer Himalayan Region of the Upper Punjab. Quart. Journ. Geol. Soc. vol. xxx. pp. 61–80 (1874).

H. B. Medlicott. Note on the Sub-Himalayan Series in the Jamu (Jummoo) Hills. Rec. Geol. Surv. Ind. vol. ix. pp. 49–57 (1876).

A. B. Wynne. Note on the Tertiary Zone and Underlying Rocks in the North-Western Punjáb. Rec. Geol. Surv. Ind. vol. x. pp. 107–132 (1877).

——— Notes on the Physical Geology of the Punjab. Quart. Journ. Geol. Soc. vol. xxxiv. pp. 347–375 (1878).

H. B. Medlicott. Manual of the Geology of India. Cap. 22, 23, 25, 26, 27 (1879).

W. Theobald. The Siwalik Group in the Sub-Himalayan Region. Rec. Geol. Surv. Ind. vol. xiv. pp. 66–175 (1881).

H. B. Medlicott. The Nahan-Siwalik Unconformity in the N. W. Himalayas. Rec. Geol. Surv. Ind. vol. xiv. pp. 169–174 (1881).

R. Lydekker. Geology of the Kashmir and Chamba Territories, and the British District of Khagan. Mem. Geol. Surv. Ind. vol. xxii. (1883).

R. D. Oldham. Note on the Geology of the Gangasulan Pargana of British Garhwal. Rec. Geol. Surv. Ind. vol. xvii. pp. 161–167 (1884).

——— Memorandum on the Probability of Obtaining Water by Means of Artesian Wells in the Plains of Upper India. Rec. Geol. Surv. Ind. vol. xviii. pp. 110–112 (1885).

C. S. Middlemiss. Physical Geology of the Sub-Himalaya of Garhwál and Kumaun. Mem. Geol. Surv. Ind. vol. xxiv. part 2 (1890).

NOTICES OF MEMOIRS.

I.—Prof. W. Dames on a Swedish Cretaceous Bird.

"Ueber Vogelreste aus dem Saltholmskalk von Limhamn bei Malmö." By W. Dames. Bihang till k. Svenska Vet.-Akad. Handl., vol. xvi. pt. iv. No. 1, with plate (1890).

In this paper Professor Dames discusses associated right humerus, coracoid, and scapula, apparently of a bird, obtained by Professor Lundgren from the Upper Senonian of Southern Sweden. In the course of his introductory remarks he alludes to the possible occurrence of a gadoid fish in the same formation—the determination being apparently based upon the original example of *Dercetis limhamnensis* of Davis. A detailed description of the bird-bones follows, and the provisional name of *Scaniornis Lundgreni* is proposed for the genus and species they represent. All known carinate birds from the American and European Cretaceous and Tertiaries are successively reviewed in comparison; and a reference to recent skeletons suggests that the new extinct Swedish type is a primitive wader. A. S. W.

II.—The Geology of the Long Mountain, on the Welsh Borders. By W. W. Watts, M.A., F.G.S.[1]

THE author described the Silurian succession in a part of West Shropshire and East Montgomeryshire.

1. May Hill grit, sometimes conglomeratic, containing one richly fossiliferous band of limestone at Cefn, Buttington, This is traced from Cefn to the north end of the Breidden Hills, where it appears to thin out. It rests unconformably on various members of the Bala group, and at Cefn a small dyke of diabase is intruded along the junction line.

2. Purple and green shales with very rare fossils, chiefly Entomostraca and small Brachiopods.

3. Wenlock mudstones, earthy in the lower part, and more calcareous above, containing *Cyrtograptus Linnarssoni*, *Monograptus Flemingii*, *M. dubius*, and *M. serra*. These beds appear to represent the upper part of the Wenlock shale and the Wenlock limestone.

4. Thin muddy shales with rare flaggy ribs, containing *Monograptus colonus*, *M. Nilssoni*, and *Cardiola interrupta*; these are the equivalent of the Lower Ludlow beds.

5. Hard thick flags, with occasional shales. *Monograptus Leintwardinensis*, *M. Salweyi*, *M. Roemeri*, the equivalent of the Aymestry limestone.

6. Thin fissile shales almost barren, but with *Cardiola*. These occupy the place of the Upper Ludlow Rocks. Above these beds comes an outlier of the Passage-beds with *Lingula* and Entomostraca.

The structure of the range is a large syncline with a steep dip on the north-west side, but this is complicated by several dip- and strike-faults and one or two small synclines.

The author acknowledged the great help rendered by Professor Lapworth in determining the Graptolites.

[1] Abstract of a paper read at the British Association for the Advancement of Science; Leeds, September, 1890; Section (C) Geology.

REVIEWS.

I.—North American Crinoidology.

S. A. Miller.—Structure, Classification, and Arrangement of American Palæozoic Crinoids into Families. Amer. Geol. Vol. vi. No. 5, pp. 275-286, and No. 6, pp. 340-357. Minneapolis, Nov. Dec. 1890.

THAT erudite and enthusiastic writer Mr. Samuel A. Miller of Cincinnati, already famous through his "North American Geology and Palæontology," described by Prof. John Collett as "the most valuable and learned work on Geology and Palæontology ever published," again compels the attention of the scientific world by the elaborate article before us.

Mr. Miller has an extensive and peculiar acquaintance with Crinoids, *i.e.* with those from the Palæozoic rocks of N. America, and has proposed a large number of generic and specific names, some of which will probably stand. What more is needed? Indeed, Mr. Miller himself ridicules P. Herbert Carpenter for supposing that a knowledge of recent forms is of any advantage to the student of fossils. Besides this, Mr. Miller's specific names are never spelled with a capital letter,[1] and they can all be translated by the aid of Andrews' Latin Lexicon. But, for all his learning, Mr. Miller is not proud; he modestly writes as though he could read no language except his own and English. Mr. Miller has too that rare merit in a scientific man—consistency: he never (or hardly ever) changes his opinion, and consequently has earned the right to abuse Wachsmuth for changing his with the progress of knowledge. At the same time it must not be supposed that the classification now put forward by Mr. Miller is the same as that adopted in his "North American Geology." He is careful to explain that it was not then his object "to write an original treatise on any one branch." We are surprised, for that classification struck us as one of the most original we had ever seen.

Discarding the puerile speculations of recent writers as wholly unsupported by fact, Mr. Miller reverts to a classification according to superficial similarities of structure, a method which, with the advantage of simplicity, combines the sanction of antiquity. He, at least, will not follow the vagaries of those who consider a certain character of family value in one place and of barely specific importance in another.

Mr. Miller cannot away with your Morphologist; hence he has never accepted the view that the median circlet of plates in the cup of a dicyclic Crinoid is homologous with the proximal circlet in a monocyclic Crinoid. For him the "basal" plates are always those next the stem; to these the animal was, he states, attached by ligament: *hence* these plates are "the most important in classification of any of the plates in the calyx." The difficulties presented by the numerous pseudo-monocyclic forms do not trouble Mr. Miller,

[1] Except when a patriotic printer insists on a large A for "Americanus."

for he does not undertake to deal with Crinoids other than Palæozoic, and, as for these, he boldly asserts that "'rudimentary underbasals' could never have had an existence in any of them." "The number of basals and the shape of the basal disk are of the first importance" in classification; for, as Mr. Miller points out, the number gradually decreases in geological time, and of course no sound thinker could imagine that later forms arise from earlier by descent with modification.

"The only known function of the subradials is to increase the capacity of the visceral cavity, ... in some genera they cover half the calyx, ... in all cases they materially affect the form and structure, ... where . . . . large they were supported by ligaments . . . . or by denticulated edges . . . . Therefore [how subtle is this logic!]—no family should include genera having subradials and those in which they do not exist."

"The next family character will be found in the presence or absence of regular interradial plates," while the last lies in the structure of the posterior interradius.

"The structure of the arms," Mr. Miller thinks, "is never of family importance, and above the brachials never of generic importance though always of specific value." As we are not informed what sense Mr. Miller chooses to apply to the term "brachials," we can offer no opinion on this point.

We have not space to give a synopsis of Mr. Miller's classification, but a few of the most noteworthy changes may be quoted for the delight of those who appreciate common-sense. Thus:—the Symbathocrinidæ are ranged alongside the Calceocrinidæ: the difficulty of separating species of *Forbesocrinus* from those of *Ichthyocrinus* can exist no longer now that the two genera are placed not only in different families but in separate groups; while matters are still more simplified by the approximation of *Ampheristocrinus* and *Closterocrinus* to the "Ichthycrinoidæ." Again, forms hitherto foolishly placed so far apart as *Eucalyptocrinus*, *Mariacrinus*, and *Xenocrinus*, are now to be found in the same group of families. In the Cyathocrinidæ are gathered *Bursacrinus*, *Carabocrinus*, *Graphiocrinus* and others, even including *Cyathocrinus*.

But for the rest of this exciting and amusing article we must refer our readers to the Christmas number of the "American Geologist" for 1890. And we would especially recommend its perusal to our younger readers; for there they will find exemplified a lucidity of exposition, an accuracy of argument, and a courtesy in debate that remind one of the Society upon the Stanislaus, though from the Report of that body even Mr. Miller might profit. The journals in which we publish may be "conduits of ignorance and conceit." We are "illiterate," "reckless of symmetry," "shallow pretenders" "venting stupid hypotheses"; in our "unenlightened affectation" we make our "usually poor English more incomprehensible" by quoting "snatches from German authors," we give full references, and we never have more than 30 misprints in 18 pages (Mr. Miller rises to 40). Yes! we are all this; we do all this: and yet, "overgrown"

with "ignorance, assumption, and conceit" as we are, we humbly confess that on this side the Atlantic we have never produced anything that would, for sweet reasonableness and smoothness of persuasion, stand a moment's comparison with the gentlemanly polemics of Mr. S. A. Miller, Cincinnati, O.

II.—Mr. James W. Davis on Scandinavian Cretaceous Fishes.

"On the Fossil Fish of the Cretaceous Formations of Scandinavia." By James W. Davis, F.G.S., F.L.S. Trans. Roy. Dublin Soc. [2] vol. iv. pp. 363–434, pls. xxxviii.–xlvi. (November, 1890.)

OF all extinct fish-faunas, that of the Cretaceous period is gradually becoming the best known, on account of the abundance in which remains are discovered in every part of the world. A large proportion of these remains are too imperfect for precise determination; but they suffice, at least, to make known the geographical distribution of the principal types, and the fossils of a few areas—*e.g.* Britain, Westphalia, Syria, Brazil, and Western North America—are so admirably preserved as to form definitely determined standards for comparison. Mr. Davis' new Memoir is the latest contribution to the subject, and comprises a beautifully illustrated account of the Upper Cretaceous Fishes of Southern Sweden, with its adjacent islands, and the neighbouring shore of Denmark.

Apart from incidental references, the Cretaceous fish-fauna of this northern region has hitherto remained quite unknown, and ichthyologists are much indebted to the Curators and Professors of the Scandinavian Museums and Universities for entrusting all their collections to a specialist for elucidation. Mr. Davis' researches are based upon materials from the Swedish State Museum, the Swedish Geological Survey, and the Universities of Lund and Copenhagen. On the whole, the specimens are of a very fragmentary character, but most of them are at least generically determinable, and many appear to be specifically identical with well-known forms from Britain and other areas. The great interest of the collection consists in the fact, that while it is in part derived from truly Senonian horizons, the majority of the specimens were obtained from the Danian series. Some of the species, therefore, are of a decidedly Tertiary character. Prof. Bernard Lundgren supplies important stratigraphical information which is tabulated at the end of the memoir; and from this table may be perceived at a glance the geographical and geological range of the thirty-four species described.

Most of the fossils under discussion, as might naturally be expected, are Elasmobranch teeth; and the author's introductory remarks deal chiefly with the classification of the Cretaceous Lamnidæ. While adopting to a large extent the arrangement formulated in the British Museum Catalogue of Fossil Fishes, Mr. Davis prefers to revert to the Agassizian conception of *Otodus* and *Odontaspis*, and is uncertain whether any ichthyologist hitherto has philosophically determined the limits of *Carcharodon*. The principal difference

between the Catalogue just cited and the memoir now before us consists in the fact that the former attempts to treat the fossils as remains of genera and species of Elasmobranchs, while the latter deals with them as so many "forms" of detached teeth, which can be distinguished and thus variously named.

Among features of special interest relating to the Elasmobranchs, may be noted the occurrence in the Danian of typical examples of *Ptychodus decurrens*, *P. mammillaris*, *Notidanus microdon*, *Oxyrhina Mantelli*, and the so-called *Otodus appendiculatus*—all well-known Cretaceous forms. With these are found an undetermined species of *Myliobatis*, and some apparently new forms of *Scapanorhynchus*, *Oxyrhina*, *Lamna*, and *Scyllium*, besides a large imperfect tooth of *Notidanus* indistinguishable from *N. dentatus* of the New Zealand Greensand. An *Odontaspis*, both from the Senonian and Danian, is also identified with a New Zealand species (*O. acuta*); but we venture to think that this is the well-known European Danian species, *O. Bronni*, to which the author makes no reference. The so-called *Odontaspis acutissima* and *O. faxensis* are undoubtedly teeth of *Synechodus*, as proved by the form of the root; and, as remarked by the author himself, there is much doubt about the generic determination of the beautiful new teeth described as *Oxyrhina Lundgreni*. Though often recorded from the Cretaceous, it is still very uncertain whether the typically Tertiary species, *Odontaspis elegans*, ranges so far downwards, and the smooth teeth assigned to this form by Mr. Davis are far from conforming to Agassiz' original definition; but the occurrence of a tooth indistinguishable from the so-called *Otodus obliquus* in the Upper Senonian of Rugaard is a fact of great interest. A portion of a tooth of *Carcharodon* from the Danian of Faxoe is even identical in character with the teeth of the existing *C. Rondeleti*, but this scarcely suffices for certain determination.

Some Chimæroid teeth from the Senonian appear to pertain to the widely distributed species, first described from Switzerland as *Ischyodus Thurmanni* and afterwards re-described in Britain under the name of *Ischyodus brevirostris*. *Edaphodon*, however, remains unknown, and there are no traces of *Elasmodus*.

Of Pycnodonts, there occur only teeth which are referred with much probability to *Cœlodus subclavatus*; and of Teleosteans there is only evidence of about six genera. Of the latter, the finest specimens pertain to *Hoplopteryx* and to a new deep-bodied physoclystous fish, which receives the name of *Bathysoma Lutkeni*. *Berycopsis* and *Dercetis* also seem to be represented; another fossil is provisionally named *Clupea Lundgreni*; and some specifically indeterminable teeth of *Enchodus* are recorded. With regard to *Enchodus* we would remark that the author does not seem to have studied the most recent discoveries, and thus assigns the genus still to the family Trichiuridæ. Here is also placed *Bathysoma*, though a critic noting the fact will perhaps be answered again in the words of the foot-note on p. 369, that the arrangement is due to "the omission of a line." *Bathysoma*, indeed, is one of the most remarkable Cretaceous fishes hitherto discovered, and we only regret that a more satisfactory determination

of its affinities has not been attained. So far as the terms of the "generic definition" are concerned, the name will apply equally well to a sole or a sun-fish; but the fine figures and detailed description of the fossils help to compensate for the insufficiency of the diagnosis.

The memoir as a whole makes an important advance in our knowledge of the Upper Cretaceous Fishes of Western Europe, and ichthyologists are much indebted to the author for providing so many new facts that will assist in future generalizations.

A. S. W.

III.—Dr. E. Fabrini on Machærodus.

Machærodus (Meganthereon) del Valdarno Superiore, Memoria del Dott. Emilio Fabrini. (Boll. R. Com. Geol. 1890, Nos. 3–6, pp. 43, pls. 3.)

THE present Memoir is another of the series intended to illustrate the extinct Mammalian fauna of Italy, reference to which has already been made in our issue of last month.

The author describes in full detail, with excellent illustrations, all the more important remains of Sabre-toothed Tigers (*Machærodus*) from the Pliocene of the Val d'Arno preserved in the Italian Museums. He concludes that two species have hitherto been confused together under the name of *M. cultridens*. In that species the upper canine teeth of the male are long and narrow, and have no serrations on their trenchant edges; and it is believed that the smaller skulls and jaws which have been regarded as representing a distinct species—*M. meganthereon*—are really referable to females of *M. cultridens*. A second new species designated *M. crenatidens* is distinguished by the shorter and wider canine teeth of the males, in which both the front and hind edges are strongly serrated. In accordance with the contour of the canine the hollow in the flange of the lower jaw, against which they are applied, is likewise unusual. It is considered that the lower jaw from the Norfolk Forest-bed, described by the late Mr. Backhouse in the Geological Society's Journal, is referable to this form, whereby a new species is added to the British Fauna.

A second new species, which it is proposed to designate *M. nestianus*, is characterized by the upper canine teeth carrying serrations only on their hinder edges; and likewise by the long gap separating the third and fourth premolars in the lower jaws. It is suggested that it may be advisable to regard this species as the type of a new genus, in which case the name *Homotherium* might be adopted.

R. L.

IV.—Sur la nature Végétale de l'Aachenosaurus multidens G. Smets. Par Dr. Maurice Hovelacque. (Mem. Soc. Belg. de Géol. iv. (1890) p. 59 *et seq.*)

THE "wooden Dinosaur"—as the so-called *Aachenosaurus multidens* has not inaptly been termed on this side of the Channel—has at length received its *coup de grâce* at the hands of the author of this

memoir. The vegetable nature of the fossil could not possibly be disputed by any one who examines the descriptions and figures in the text with the accompanying plate; or who, like the writer of this notice, has had the privilege of seeing sections of the "bones" under the microscope. The two fragments examined by Dr. Hovelacque, viz. the so-called *épine dermique* and *máchoire*, he shows to belong to two different families of plants, and they now receive the names of *Aachenoxylon* and *Nicolia Moresneti* respectively. G. F. H.

V.—La Faune Tertiaire Marine de Carry, de Sausset et de Couronne (près Marseille). Facies des étages tertiare dans la Basse-Provence. Par M. Paul Gourret. (Mem. Soc. Belge de Géol, iv. (1890) pp. 73–143, with four plates.)

THE author commences by giving a general outline of the Tertiary beds of Basse-Provence, showing that the Eocene, Oligocene, Miocene and Pliocene are each represented in that district. In this memoir he gives a few palæontological details fixing the horizons of the several beds and roughly correlating them with the Tertiary strata of adjacent areas.

The second part enumerates the species found at the three places mentioned in the title of the memoir, and under the heading of each of these species are placed the names (where necessary) of what the author considers to be synonyms, together with a brief account of its geologic and geographic distribution. with occasional critical remarks. This is the most important section of the paper, and it is put forward as a revision of the whole fauna and as the result of much careful research. In all, 301 species of fossils are recorded, which are distributed as follows: — Pisces 8, Crustacea 5, Mollusca 247, (Gasteropoda 157, Pelecypoda 90), Polyzoa 6, Brachiopoda 3, Echinodermata 13, Cœlenterata 19. The Fish belong to the genera *Lamna*, *Myliobates*, *Oxyrhina* and *Sphærodus* (*sic*); whilst the Crustacea are mainly *Balani*. The Mollusca naturally claim a large share of attention, and it may be remarked that in dealing with them, the author does not adhere to certain well-known and generally accepted rules of nomenclature, which is much to be regretted. For example, when the generic appellation of a species is changed, he inserts the name of the individual who made the alteration after the specific, instead of that of the original describer of the species. The science of Malacology has made great strides during the past ten years, but this fact has not been sufficiently recognized in the memoir now under review. It would be tedious to point out all the shortcomings in this respect, but we may mention *Pyrula melongena*, Bast., which should be *Melongena cornuta*, Ag.; *Pyrula bulbus*, Desh. = *Sycum bulbus*, Sol.; *Buccinum baccatum*, Bast. = *Cyllenina baccata*, Bast.; *Buccinum reticulatum*, Linn. = *Nassa reticulata*, Linn.; *Voluta rarispina*, Lam. = *Volutilithes rarispinus*, Lam.; *Ancillaria* = *Ancilla*; *Chenopus* = *Aporrhais*. Again, no attempt is made to classify the larger groups — the heterogeneous assemblage of forms which were included under such

genera as *Pleurotoma*, *Fusus*, *Buccinum*, *Bulla*, *Cerithium*, *Natica*, *Venus*, etc., during the first decades of the century, are still classified as they then were, in the lists of the fossils from Marseilles before us. The synonyms given are in many instances inaccurate also. It may be said that the second section of the memoir is useful as giving an idea of the richness and general character of the fauna of the Upper Tertiary beds of the localities mentioned, and at any rate it is something to have a complete list of the known species, even although some may be wrongly determined; but the whole requires very careful revision before it can be of any material value to the systematist.

The third section gives the distribution in detail of the fossils found, showing their vertical and horizontal ranges, and this is unquestionably the most useful portion of the work. The four plates, which are beautifully executed, re-figure certain characteristic Mollusca and depict five new species which are described in the text.

G. F. H.

VI.—Catalogue of Minerals for Sale. By Geo. L. English and Co. 8vo. Philadelphia and New York, 1890. Price 25 cents.

THIS book is no mere dealer's catalogue, but contains a large amount of useful information, concisely arranged for ready reference. A brief résumé of the more recently described minerals is given, followed by a classification and list of all known minerals arranged according to their chemical composition. In this list the crystallographic system and the general formulæ are mentioned, and the whole is rendered more complete by a good index at the end of the volume. Several figures are given, including eight fine crystals of Beryllonite from Stoneham, Maine.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—December 17, 1890.—W. H. Hudleston, Esq., F.R.S., Vice-President, in the Chair.—The following communications were read:

1. "On Nepheline Rocks in Brazil.—II. The Tingua Mass." By O. A. Derby, Esq., F.G.S.

In a former paper the general distribution of the nepheline rocks, so far as known, was given with a particular description of a single one, the Serra de Pocos de Caldas. The present paper treats of a second mass, the Serra de Tingua, a high peak of the Serra do Mar, some forty miles from Rio de Janeiro.

The peak is essentially a mass of foyaite rising to an elevation of 1600 metres, on the crest and close to the extremity of a narrow gneiss ridge of a very uniform elevation of about 800 metres. As seen from a distance, the conical outline and a crater-like valley on one side are very suggestive of volcanic topography. In the structure of the mass both massive and fragmental eruptives are found, the former greatly predominating.

The predominant rock is a coarse-grained foyaite which is found everywhere in loose blocks about the margins of the mass, but not extending beyond it. In the numerous cuttings in the immediate vicinity, dykes of phonolite and basic eruptives (augitite) are exceedingly abundant, foyaite never appearing in a dyke form. There is, however, abundant evidence that foyaite and phonolite are but different phases of the same magma.

Aside from the dyke phonolites, true effusive phonolites associated with fragmental eruptives (tuffa) were found high up in the crater-like valley, proving that the mass was a volcanic centre in the most restricted sense of the word.

This conclusion affords an explanation of some of the peculiarities of the foyaite, which has many characteristics of effusive eruptives mingled with those of the deep-seated ones (*Teifengesteine*). These have, aside from the porphyritic structure, a *schlieren* structure revealed by a peculiar fluted weathering (illustrated by a photograph) and the presence of pseudo-crystals in the form of leucite.

Statigraphically the Tingua foyaites lie in sheet-like masses like lava-flows, extending from the higher to the lower portions of the mountain, the underlying gneiss being revealed at nearly all levels, wherever the mass has been scored by streams. The general fragmentary character of the rock seems to be due to the undermining of these sheets.

Specimens and photographs illustrating the peculiar pseudo-crystals in the form of leucite that occur in both the foyaites and phonolites of Tingua (although no leucite has been detected in the rock) were exhibited and discussed.

2. "The Variolitic Diabase of the Fichtelgebirge." By J. Walter Gregory, F.G.S., of the British Museum (Natural History).

The author has examined the variolitic diabases in the neighbourhood of Berneck, and adduces evidence of their having been intruded into the Devonian rocks before the latter were affected by the great earth-movements which have folded the Palæozoic rocks of the district. He finds that the variolitic structure occurs in two different arrangements: (*a*) on the surfaces of spheroidal masses of compact diabase, which are comparable with those of Mt. Génèvre; (*b*) as a true contact-product on the selvage of the diabase, the latter being comparatively rare, and the varioles less perfectly developed.

He gives proofs that the varioles are true spherulites, and not fragments of Devonian rocks, as supposed by von Gümbel. He argues that though they are the product of rapid cooling, too sudden a solidification of the diabase may prevent their formation, and that for a similar reason the amygdaloidal is less variolitic than the compact diabase, the loss of the water that occupied the vesicles having diminished the fluidity of the rock. Finally, he maintains that the "pseudo-crystallites" are rifts and fissures due to contraction, and that the remarkable optical properties described by Michel-Lévy are due to the filling-up of cracks by felspathic matter deposited in optical continuity with the crystalline fibres on each side.

II.—January, 7, 1891.—A. Geikie, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the North-west Region of Charnwood Forest, with other Notes." By the Rev. E. Hill, M.A., F.G.S., and Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

The paper contains the results of a re-examination of the North-west Region, when the authors had the advantage of using the Six-inch Ordnance-map, published since the completion of their former work. In this they had expressed the opinion that the rock of Peldar Tor and that of High Sharpley were somewhat altered pyroclastics, being much influenced by the non-igneous origin asserted for the "porphyroids" of the Ardennes. But in 1882 one of them had visited this region, and was then convinced that the porphyroids, which closely resembled the rock at Sharpley, were felstones which had been rendered schistose by subsequent pressure. The result of their subsequent work in Charnwood has convinced the authors that the rocks of Sharpley and of Peldar Tor are in the main of a like origin and history. The mass of Bardon Hill, where the quarries have been much enlarged, has also been studied, and some details in the section formerly published have been corrected. The schistose bands, on which the authors relied as marking horizons for stratigraphical purposes, prove to be zones of exceptional crush. The occurrence of a rock exactly resembling that of Peldar Tor is fully established. It is extremely difficult to decide upon the true nature of the rocks which are chiefly worked in the pit, but the authors remain of opinion that for most of them a pyroclastic origin is the more probable.

Some notes are added upon the relations of the holocrystalline igneous and the sedimentary rocks of the Forest, upon the Blackbrook group, and upon the fragments and pebbles in certain of the coarser ashy deposits. Some remarks are made upon the glacial phenomena exhibited in the Forest-region; these indicate that this cannot have been overridden by a great northern ice-sheet and it does not afford the usual signs of the action of local glaciers. At the same time it has been a centre of dispersion for erratics, especially towards the south and south-west, these being found sometimes more than twenty miles away. Hence, in the opinion of the authors, the erratics have been distributed by floating-ice during an epoch of general submergence. Some minor "Corrigenda" in the earlier papers are noted, with certain changes in the names of localities, bringing them into harmony with the Six-inch map.

2. "Note on a Contact-Structure in the Syenite of Bradgate Park." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

The author described a specimen, obtained at Bradgate Park, showing a junction of the syenite and slaty rock of Charnwood. The latter rock is very slightly altered; the former exhibits a number of grains of felspar and quartz set in a matrix which has now a "trachytic," now a devitrified structure. He traced the former into the "micrographic" structure observed generally in these syenites, and discussed its significance. His study of these

structures in this and many other instances led him to infer that they generally indicated that the rock, at a late stage, had consisted of a mixture of previously formed crystalline grains and a viscous magma, that the temperature of the mass has been comparatively low, that it had cooled rather gradually, and that the condition of the magma—*i.e.* one of very imperfect fluidity—had not permitted of free molecular movements among its constituents. Thus this structure, together with certain others mentioned, might be regarded as indicative of "crystallization under constraint."

3. "On the Unconformities between the Rock-Systems underlying the Cambrian Quartzite in Shropshire." By Charles Callaway, D.Sc., F.G.S.

I. *Review of the Evidence for the respective Ages of the Uriconian and Malvernian Rocks.*

The author criticizes the conclusions arrived at by Prof. Blake (Q.J.G.S. 1890, p. 386), and adduces evidence to show :—

(1) That the felsites regarded by himself as Archæan have *not* been shown to be intrusive in Longmynd Rocks.

(2) That it has not been proved that the Longmynd Series is divisible into two groups, separated by an unconformity; and that, therefore, the evidence from included fragments remains unaffected.

(3) That the conglomerates and grits associated with the Uriconian are an integral part of that system, and are not of Cambrian age; and that the granitic and metamorphic land-masses from which so many of the fragments in the conglomerates are derived are consequently of pre-Uriconian age.

(4) That the granitic rocks of Shropshire are not intrusive in the Uriconian.

II. *The Relation between the Uriconian and the Longmyndian.*

Pending the publication of Prof. Lapworth's researches upon the fauna of the Hollybush Sandstone, the author regards it as hardly wise to assign positively a pre-Cambrian age to the Longmyndian system.

In favour of an actual break between the Uriconian and Longmyndian rocks, he gives details showing the general discordance of strike between the two groups; the locally concordant strikes are seen along a line of fault. Furthermore, as the junction between the two groups is faulted, this, whilst of course not proving an unconformity, renders incredible the hypothesis of conformity and igneous intrusion along the line of junction. Again, the conditions of deposit were different: the Uriconian is essentially a volcanic formation, whilst the Longmyndian rocks are characterized by their even sedimentation, and the author maintains that such a change of conditions must indicate a break in time, though the unconformity need not necessarily be very great.

Lastly, the occurrence of fragments of Malvernian granites and schists (formed at great depths) in the Uriconian Conglomerates indicates the existence of an unconformity between the holocrystalline and volcanic systems.

CORRESPONDENCE.

"STEM-OSSICLES" OF CRINOIDEA, IN THE LEPTÆNA-KALK (UPPER ORDOVICIAN) DALECARLIA, SWEDEN.

SIR,—A reviewer (F.A.B.) of my notice "Om förekomsten af en Caryocrinus i Sverige" has said in the GEOLOGICAL MAGAZINE, December, 1890, p. 570: "The rock is filled with stem-ossicles which Dr. Holm, after the curious custom of collectors, thinks it necessary to ascribe to Crinoidea." What I regard as stems of at least two species of Crinoids, the reviewer says are stems of Cystidea without his having seen a single one of them. But the real fact is that these stems in consequence of their structure must have belonged to Crinoids. One of the supposed species has left fragments of stems 45 mm. in length by 16 mm. in breadth. These show the starting-points where strong cirrhi originated, and as far as known cirrhi have not been found in the Cystidea. Thick and expanded rootlets of Crinoids are also not rare. To this must be added, that all known Cystidea from this same locality, with the exception of *Caryocrinus cfr ornatus*, Say, are devoid of a stem. According to Angelin the genera *Sphæronis*, *Eucystis* and *Caryocystis* are sessile, having the basis of the perisome itself directly affixed to foreign bodies without the mediation of a stem, and several of the specimens observed by me of *Sphæronis oblonga*, Ang., and *Eucystis sp.*, either show the surface by which they were attached, or are even yet affixed to Bryozoans or other marine Silurian fossils. Of *Caryocystis* I have seen only a single specimen, and this does not show the basis of the perisome clearly. A species of *Eucystis* is numerically by far the most predominant form. This is the cause why I have, with full intention, referred the stems to Crinoids.

STOCKHOLM,
15*th January*, 1891.

GERHARD HOLM.

THE DENUDATION AND ELEVATION OF THE WEALD.

SIR,—In the December Number of the GEOLOGICAL MAGAZINE, Dr. Irving states that in my sketch in the September Number I reproduced partly some arguments which he put before the Geological Society in June (May 21st, 1890?), and published in the September Number of the GEOLOGICAL MAGAZINE. I applied to Dr. Irving for particulars, and he informed me "that the argument from the raised beaches and the reference to the crag at Lenham were the points referred to."

Now, Sir, as to the argument from the raised beaches, mine is quite a different argument from that used by Dr. Irving. I use it in the course of a criticism on Sir A. Ramsay's diagram (Geol. and Geog. of Gt. Brit. 1878, p. 343, fig. 73) as a local and recent example of elevation turning a horizontal beach-line into a curve. Dr. Irving omits the fall to the west, and uses it to prove western elevation of the Wealden area.

As to the Lenham beds, I have the right to refer to them without obtaining leave.

I do not lay claim to any great originality for my little sketch, but, in fact, I did not derive my ideas from Dr. Irving's paper.

3, Pump Court, Temple, E.C. Horace W. Monckton.

REPLY TO MR. A. SOMERVAIL.

Sir,—I owe an apology to Mr. Somervail for plucking a leaf from his coronet of laurels. It is the simple truth that the paper which he cites had not in any way impressed itself on my mind, and thus (as the index for the last volume was not then published) escaped recollection. While making this atonement, I will take the opportunity of explaining to him why I use that plainness of speech to which he evidently objects. If he is right in his principal hypothesis about the rocks of the Lizard, I am so hopelessly wrong that I must begin my petrological studies *de novo*. The one or the other of us, so to say, is ignorant of the very grammar of the language. Now, as it happens, I have given, for nearly twenty years, more attention to petrology than to any other branch of geology; twice or thrice every year I have visited districts which were known to be instructive, making often long journeys in order to study some critical question. I have examined many of the most interesting localities on the Continent of Europe, a few also in Canada. I have formed a very large collection of rock specimens and microscopic slides, to the study of which I have devoted such leisure as I can command. Now in Mr. Somervail's writings no evidence appears of either wide experience or knowledge of the microscope, both of which are necessary for theorizing on difficult problems in petrology; indeed, of the latter, not so long since, he admitted his ignorance. Of course I know that many of these problems are yet unsolved; I make no claim to infallibility; I am well aware that notwithstanding all my pains I have not escaped the fate of workers in a progressive science, and have to modify or even abandon conclusions which at one time seemed most accordant with facts, but some of Mr. Somervail's hypotheses appear to me irreconcilable with facts and inductions which, not only I, but also petrologists of greater repute, accept almost as axioms. To me he appears to occupy the position in which I should have placed myself had I signalized my entrance in the "fifth form" at school by publishing "adversaria" on a trilogy of Æschylus.

T. G. Bonney.

DYNAMO-METAMORPHISM.

Sir,—M. Spring's valuable experiments have had a very stimulating effect on many minds; so much so that his experiments are sometimes quoted in proof of positions very much in advance of those taken by M. Spring himself. Thus Mr. Harker in his letter on the subject of dynamo-metamorphism in your last issue, after remarking that "the practical verification" of "the *direct* correlation of mechanical and chemical energy" "rests on such experiments

as those of Cailletet, Pfaff and Spring," refers to one of the experiments of the latter in the course of which sulphur and copper filings subjected to a pressure of 5000 atmospheres were converted into crystallized copper sulphide. Mr. Harker comments on this as follows:—"So much of the mechanically-developed energy as takes the form of heat is carefully removed; but chemical combination still takes place. It follows that the energy absorbed in this combination comes directly from the mechanical work done, without the intervention of heat."

I have no desire to interpose in the controversy between Mr. Harker and Dr. Irving, but, without doing this, I may point out that the explanation offered by Mr. Harker does not appear to be in accord with that offered by M. Spring himself.

In the American Journ. Science, xxxvi. (1888) pp. 286–289, Spring remarks regarding his "researches on the compression of powders," "To my mind pressure was not an active agent in the matter; but only the means to the end, and I looked for the effects to contact alone. . . . In another place [Bull. Soc. Chemique, 1884], I said with regard to chemical action produced by my experiments—'one must not lose sight of the fact that pressure is not a chemical agent to the same extent as heat or electricity.' But as I have always thought that *contact* was brought about by compression, I have often, for the sake of brevity, spoken of '*welding* due to pressure,' instead of always saying welding due to contact produced by compression. I now see that I was unwise in thus wishing to economise my time. Besides, as conclusive proof that it is always to contact that I assigned welding phenomena, chemical reactions, and also in part the diffusion of solids, there is the fact that I deemed it necessary to operate *in vacuo*, on account of the failures in preliminary experiments made under the ordinary conditions;" and M. Spring goes on to explain that when he did not operate *in vacuo* the presence of air between the particles hindered intimate *contact* between them and thus prevented chemical action, pressure notwithstanding.

In a previous communication to the American Journ. Science (vol. xxxv. 1888, p. 78) Mr. Spring wrote: "Since then [1880] new experiments, still in part unpublished, have made me recognize the importance of the part that a certain degree of temperature plays in these phenomena, so that for the solid state, as well as for the gaseous one, a *critical temperature* would be remarked, above or below which the changes of simple pressure would be no longer possible."

Spring, therefore, in the conclusions arrived at as recently as the close of 1888, attributes the chemical action set up in his experiments to *contact* plus a certain degree of *temperature*. Pressure is merely the matrimonial agent, so to speak, that brings the highly susceptible particles together; but it is to *contact* plus *heat* that, according to Spring, the chemical action is due.

C. A. McMahon.

20, Nevern Square, 12*th Jan.* 1891.

FUNNEL-HOLES ON LEBANON.

Sir,—The nmerous funnel-holes upon the tops of the Lebanon and Anti-Lebanon Mountains afford striking examples of the power of solution and chemical disintegration unsupplemented by the action of torrents. My attention was directed to these holes last spring by Dr. Wm. T. Van Dyck, of Beirût, who also suggested a theory for their formation. A summer journey, which took me to the tops of nearly all the mountains of Lebanon and Anti-Lebanon as well as to Mount Hermon and the Anseireh Mountains, gave me an unusually good opportunity to observe these phenomena and enabled me to verify and somewhat amplify the idea suggested by Dr. Van Dyck.

The higher portions of the mountains visited were from 6000 to 10,500 feet above the sea-level. Below the level of 5000 feet their sides are worn by running water into very rough and precipitous gorges. Our attention was quite forcibly called to this feature by the great difficulty of climbing among the lower slopes. Above 6000 feet however the slopes become more rounded and the surface of the ground more smooth, until on the broad summits of some of the highest mountains carriages might safely be driven. This is markedly true of the summit plateau of the most lofty of all, the Ḍuhr-il-Ḳaḍîb, sometimes called the Fem-il-Mezâb. The lower slopes of the mountains in the winter and early spring abound with rushing torrents, but in the long summer these portions are perfectly dry, except in those rare and precious spots where there are springs. Here, consequently, the forces of disintegration are active during the winter and spring, and most of the *detritus* is washed away at once, leaving the rocks rugged and bare.

Different conditions are found in the upper regions. The thawing of the snow is gradual, so that probably the larger portion of the water, instead of running off, sinks into the ground, which on the heights is composed of a thick layer of more or less finely comminuted chips of stone over the solid rocks *in situ*. Even late in the summer we found on the eastern side of every favourably situated ridge or peak a large mass of snow sheltered from the prevailing warm west wind, and melting a little every day from about noon until sunset. At the foot of every such mass of snow was a funnel-shaped hole into which trickled every afternoon a tiny stream of water. We observed also many other such holes from which the snow had gone. The diameters of these across the top ranged from a few feet to one hundred yards, and the sides usually sloped at angles of from 15° to 40° straight to a point at the bottom, making inverted and irregular, but yet complete rather than truncated cones. The western side was usually the steeper. I may add that most of these holes occur in a compact limestone generally considered to belong to the Middle Cretaceous period, and further, that the *strata* can be traced as almost perfectly level for miles along the sides of these summits.

It follows then that the principal agency in the formation of each

of these funnel-holes must have been the chemical and solvent action of the water from its own snowdrift, aided to some extent by the mechanical work of the frost. ALFRED ELY DAY.

SYRIAN PROTESTANT COLLEGE, BEIRÛT.

ELEVATION AND SUBSIDENCE DURING THE GLACIAL PERIOD.

SIR,—In reply to the article by A. J. Jukes Browne (GEOLOGICAL MAGAZINE, December, 1890, p. 561), concerning high continental elevation of America with relation to the Glacial period, I may refer to my appendix in Prof. G. F. Wright's "Ice Age in North America," as containing a review of evidences of subsidence in the West Indies, cited in that article, probably contemporaneous with the elevation and glaciation of the northern part of North America. It was pointed out fifteen years ago by Dr. Ricketts (GEOL. MAG. Dec. II. Vol. II. 1875, pp. 573–580) that submergence of the Isthmus of Panama may have been an important element in the causes of the Glacial period; and at about the same time the collection by Dr. G. A. Maack of abundant Pleistocene fossils, "all living up to the present time," in the vicinity of the Panama railroad, and at many localities southward to the Atrato river, ranging in height up to at least 763 feet, while the lowest points of the interoceanic water-shed are less than 300 feet above the sea, gave proof that parts of this isthmus have been thus lately submerged (Reports of Explorations for a Ship Canal, Isthmus of Darien, United States Navy Department, Washington, 1874, pp. 155–176).

Nothing is more surely determined than the record of the Glacial period, as shown by glacial drift and striæ upon North America from the Atlantic to the Pacific, and from southern Illinois to the Arctic Sea, and upon north-western Europe from the British Isles to Germany and Central Russia, and northward across the Scandinavian peninsula. Some causes must have existed to produce the great climatic changes of this period. These causes seem to me to have been probably the great uplifts of the glaciated areas of which Professor Spencer has cited so much evidence, and the contemporaneous depression of the region of the West Indies and Isthmus of Panama, by which a part of the equatorial oceanic current that sweeps northward in the Gulf Stream would be permitted to pass into the Pacific Ocean, withdrawing a large portion of its heat from the North Atlantic area. Correlative northern elevation and southern subsidence, for both of which we have sufficient proof, would contribute almost equally to the climatic changes of the Ice age. This subject, and the probably contemporaneous uplift of a belt of land across the North Atlantic from France and Great Britain to the Færöe Islands, Iceland, and Greenland, as argued by Prof. James Geikie in his "Prehistoric Europe," I have discussed somewhat fully in the American Geologist for December, 1890, and the American Journal of Science for January, 1891, in the endeavour to ascertain the probable causes of the remarkable Quaternary changes of climate. WARREN UPHAM.

SOMERVILLE, MASS., *January 6th*, 1891.

PHYSICAL GEOLOGY OF THE SUB-HIMALAYA.

Sir, — May I be permitted a few remarks in reply to Mr. Medlicott's review of my memoir in this Magazine for October, 1890? I cannot attempt to answer objections of a theoretical nature, or of purely local interest to us in India; but on one or two points where I think Mr. Medlicott has mistaken my words or my meaning I would say a word or two. With regard to the fault at Jirinjala in my horizontal section No. V., which Mr. Medlicott says "seems uncalled for," I must plead that the fault is nevertheless there, as plainly visible in the natural sections exposed as in my drawn section. It is not a fault inserted to meet a theoretical requirement. The firm lines in all my sections indicate facts (when not otherwise stated in the text), whilst the dotted lines alone represent inferential conditions of the rocks. The large scale, four inches to the mile, maps would have fully satisfied Mr. Medlicott on this point had they been procurable. In speaking of, and representing, the main boundary, the Nahan-Siwalik boundary, and others, as faults, I hope I have not "ignored their primary and most interesting character" (see p. 118–123 of my memoir). They are certainly faults *now*—sometimes with miles of throw or thrust (see p. 66); hence to lay them down on the map as natural boundaries, because they originally grew out of such, would be a very grave error. It would be akin to representing the lie of the beds as horizontal, for the reason that they were originally deposited so. In addition it must be remembered that the present faulted boundaries are not absolutely, but only approximately, coincident with the original limits of deposition. In some cases, as at Jirinjala, the original boundary, and the approximately coincident faulted boundary, are both present, and need a separate and distinct method of representation.

The difference between section VI. and section IX. with regard to the position of the Nummulitic and Tal beds on the subjacent rocks, is owing to the thinning out of the Massive Limestone, or to its previous erosion. This is plainly illustrated in the map accompanying my paper on the "Physical Geology of W. British Garhwal" (Records G. S. of I. vol. xx. pt. 1). To state, as Mr. Medlicott has done, that my "facts in favour of an earlier plication of the Himalayan rocks are only quotations of wholesale differences of strikes in that region," is to simply misquote me, as the first words on page 127 of my memoir will make evident.

In criticising Mr. Mellard Reade's theory of mountain-formation, as applied to the Himalaya, I did not impute blunders to Babbage and Herschel "in the elements of science." What I did was to show that Mr. Reade's application of the Babbage-Herschel theory in the case of *great sedimentation* was unsound. Again, though the Babbage-Herschel principle may involve the idea of a "fluid substratum," as Mr. Fisher's theory does, the same is not true of Mr. Reade's theory, with which I was concerned. The latter expressly assumes the earth to be solid.

C. S. Middlemiss.

Abbottabad, Panjab, 12*th December*, 1890.

DYNAMIC METAMORPHISM.

SIR,—All that is contained in the letters of Mr. Fisher and Mr. Harker in the January Number of the GEOLOGICAL MAGAZINE can be, I think, fully and completely answered, though not within the space of a short letter. All that Mr. Fisher's high "authority" has put forward is very well known to students of chemistry, and was before my own mind, when I wrote my previous letter. I will only here repeat my former statement (attaching now to the phrase the meaning I did then) that "chemical combination must generate heat."

WELLINGTON COLLEGE, BERKS, A. IRVING.
25th Jan. 1890.

MISCELLANEOUS.

PROFESSOR SIR WARINGTON SMYTH'S SUCCESSOR.—The Lord President of the Council has appointed Dr. C. Le Neve Foster, F.G.S., Inspector of Mines under the Home Office, and formerly of the Geological Survey of England and Wales, Professor of Mining in the Royal College of Science, London, with which the Royal School of Mines is incorporated.

THE SAIGA ANTELOPE IN BRITAIN.—An interesting addition to the known British Pleistocene Fauna has recently been made by the discovery of a portion of the skull of the Saiga Antelope (*Saiga tartarica*, Linn. sp.) in the Thames Gravels at Twickenham, near Richmond. The specimen consists of the well-preserved calvarium with both horn-cores, and was obtained from an excavation in Orleans Road, Twickenham, by Dr. J. R. Leeson, F.G.S. It was forwarded to the British Museum for determination, and the interest of the discovery was recognized by Mr. Smith Woodward, who exhibited and described the fossil at the meeting of the Zoological Society on November 4th, 1890. A good figure accompanies the description in the forthcoming part of the Proceedings of this Society. The occurrence of the Saiga Antelope in the British Pleistocene Fauna has long been anticipated, characteristic remains of the animal being well known from the caverns of France and Belgium; but Dr. Leeson's fine specimen affords the first proof of its range so far to the North-west of Europe as the present Thames Valley. This unique fossil, we understand, will be placed in the Twickenham Free Library.

OBITUARY.

Cav. Abáte ANTONIO STOPPANI.—It is with deep regret we have to record the death on January 1st, 1891, of Professor A. Stoppani, who held the chair of Geology in the Royal Superior Technical Institute in Milan, at the age of 66 years. Professor Stoppani was earnestly occupied in promoting, to the best of his ability, the publication of a fine series of Memoirs on Palæontology, especially on the Mammalian fauna of the Italian Tertiaries. It is to be hoped that his successor will take an equal interest in carrying on these important labours in the cause of science.

HENRY BOWMAN BRADY,

LL.D., F.R.S., F.G.S., F.Z.S., F.C.S., ETC.,

Was born at Gateshead, Newcastle-on-Tyne, February 23rd, 1835, and died at Bournemouth, January 10th, 1891. From his father, Mr. Henry Brady, who belonged to the Society of Friends, and who was a surgeon in extensive practice for fifty years, a true lover of nature, and accomplished botanist, he inherited similar tastes; and his love of Natural History, carefully nurtured at home and at school, strengthened with his years. His first schoolmaster was Mr. Storey, an ardent naturalist, and Mr. Thos. Belt, the naturalist of Nicaragua, was his school-fellow. After an apprenticeship to a chemist at Leeds, he studied under Dr. Thomas Richardson (the late Professor Marreco being a fellow-student) in the laboratory which afterwards became the Chemical Department of the College of Physical Science. After passing the examinations of the Pharmaceutical Society, he carried on the business of manufacturing and pharmaceutical chemist in Moseley Street, Newcastle, from 1855 to 1876, when he was succeeded by his friend Mr. N. H. Martin. Mr. Brady was Member of the Council and one of the Examiners of the Pharmaceutical Society. He was the originator of the Pharmaceutical Congress, and its President in 1872–3; and he contributed valuable papers to the Pharmaceutical Journal.

In his native city he lectured on Botany at the Durham College; and he was actively associated with the eminent naturalists—Alder, Albany and John Hancock, Howse, Hewitson, Wailes, Norman, G. S. Brady (his brother), Embleton, and others; and communicated papers, chiefly on recent Foraminifera, to the Natural History Society of Northumberland and Durham and the Tyneside Field-Club. Other papers he contributed to the British Association, the Royal Society, Linnean Society, Royal Microscopical Society, the Annals and Magazine of Natural History, the Geological Society, and the Geological Magazine. His chief work, however, has been the two magnificent quarto volumes of the "Challenger" Report on the Foraminifera collected in 1873–6. He began his labour of love in 1878, and supplied the manuscript for 814 pages of text, and superintended the 115 excellent plates, in 1882–4.[1] This most painstaking and conscientious work is a perfect storehouse of facts and philosophic deductions, and is the highest work on Foraminifera. His accumulated knowledge of these organisms and their extensive literature,—his own careful researches during voyages in many parts of the world,—and his friendly intercommunication with naturalists throughout Europe—enriched this noble work with very much that could not have been expected from any other naturalist.

Among his researches Mr. Brady frequently dealt with Fossil Foraminifera, and thereby did good service to Geology. Joining

[1] The foregoing has been for the most part derived from the excellent and warm-hearted obituary in the "Newcastle Daily Journal" for January 15, 1891.